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**Managing Innovation through Cognitive Mapping**

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### **Abstract**

Innovation is an important element of strategic management (2003), and most product innovations involve cross-functional teams (Cooper and Kleinschmidt, 1994) who have some difficulty in developing a shared understanding of a particular innovation problem, which can often be characterised as a complex ill-structured problem (described as a task). This study uses an action research approach (Eden and Huxham, 1996) to explore how to develop a shared vocabulary and understanding of a task and then how to direct its growth and development.

From a review of relevant literature, five dominant influencing factors emerged that impact on a team's capability to manage the task. These dominant influencing factors are the teams: shared cognition, creative processes, task relevant knowledge development, team role development and task tracking. These were used as the building blocks in an architectural innovation. The researchers experience in innovation projects in industry and with MBA students on smaller project re-enforced this literature review.

An iterative action research process involving 160 interviews was then used to develop a new framework that positively impacted on these five dominant influencing factors in seven organisations. The seven companies selected were all at the early stage of exploring an ill-structured innovative opportunity, which formed the basis of the tasks for the various teams. These varied in their nature but all required architectural knowledge development in cross functional teams ranging from four to seven people. The framework uses as its building blocks existing established models and approaches from different disciplines.

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The developed framework broadly has the follows characteristics and building blocks:

**Developing a shared understanding:** Cognitive Mapping (Eden, 1992; Huff and Jenkins, 2002), nominal group technique (Delbecq, Van de Ven and Gustafson, 1975) and brainstorming techniques (Richards, 1999) were used to help the project teams creatively capture and develop a shared vocabulary on the uncertainties surrounding the innovation using the inputs of all the team members. The resulting map could be used by the group as a tool to communicate with outside knowledge pools as well as a memory tool.

**Developing the knowledge needed to resolve the uncertainties associated with the task:** Knowledge management, project management and innovation management processes (Delbecq, Van de Ven and Gustafson, 1975; Collison and Parcell, 2001; Fisher, Press, Chapman and Rust, 1996) were used to develop and track the teams knowledge needed to resolve the task. This required the laddering of the uncertainties that surround the task and the allocation of the uncertainties at the bottom of the ladder (called events), to the relevant team members to resolve. The interregnum between team meetings was used to resolve or develop the knowledge associated with the events, and team meetings were used to redevelop the shared cognition and update the group map.

Whilst the seven cases examined here need to be interpreted in the context of the specific organisations and their industries, it is argued that the use of this framework can benefit organisations in a variety of industries as an aid to innovation management and possibly ill-structured problems in general. The cognitive map based framework was found to be effective by participants in the study with increasing effectiveness as the full seven steps of the framework were developed.

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The contribution to the body of knowledge that the framework makes is as an architectural innovation (Afuah, 1998). It binds together proven building blocks such as cognitive mapping, nominal group technique, brainstorming, laddering, knowledge management, and project management, with uncertainty as a focus for the team to rapidly develop its task relevant knowledge.

**Key words:** Business; cognition; innovation; management; project teams; strategy; uncertainty

## **Chapter 1: Introduction**

### **1.1 *What lead to this study?***

The researcher consulted in the fields of strategy and innovation management and in many interactions with innovation teams over a five year period, was struck by how inefficient and sometimes ineffective innovation teams are. Politics, team dynamics, comfort zones and the lack of a process to develop a shared view of what must be done, too often characterised the researcher's experience in innovation teams. Reflecting on these interactions, there appeared to be a gap between practical tools that are used in the field and the body of literature that surrounded innovation management. Given the large sums that can be expended on developing innovations, there seemed to be a need to develop a process to assist these innovation teams. The researcher then began to formulate a view of what constituted the actual problem.

### **1.2 *The research problem***

Reflecting on team behaviour there seems to be a high road or low road potential to team behaviour. On the low road teams of people working on tasks which are complex and for which the path of development is unclear (ill-structured problems), can succumb to the "groupthink" behaviour described by Janus (1972). These groups talk past each other and somehow never seem to develop the vocabulary to direct and unlock the collective wisdom that the team possesses. Human nature in this context is not to push the boundaries of what is not known but rather to posture and debate around what is known by members of the team.

In contrast the high road shows in early experiments done by the British scientist Francis Galton in (1907), where if a team can unlock the collective wisdom of its members, the sum can be greater than the individual parts. Surowiecki (2005) shows in his research how under the right circumstances,

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groups are remarkably intelligent, and are often smarter than the smartest person in them. Even if most people in the group are not especially well-informed or rational, they can still reach a wise decision collectively.

This thesis uses a non-traditional approach to explore the problem of what influences which of these potential two roads a team tends towards. It develops a framework that can be used to help a team along a high road of collectively developing the knowledge to undertake innovative projects.

The reason innovative tasks are chosen as the context of study, is that most innovations involve cross-functional teams (Cooper et al., 1994), who have some difficulty in developing a shared understanding of a particular complex problem, which has an ill-defined development path as the team has little prior knowledge of the particular task (here-after referred to as task relevant knowledge).

This study uses an action research approach (Eden et al., 1996) in seven companies exploring a development with an innovation team to come up with a framework that can develop a shared vocabulary and understanding of the task in the team, and then assist in its growth and development.

The approach started with a literature review to understand the themes that influence a team on the high or low road described above. This initial review of the literature, such as that of Berczak and Wilemon (2001), revealed a number of themes that influence the ability of a team to grow the group's knowledge needed to complete an innovation project successfully. Five of these themes (henceforth called key themes) recur in the literature (Daft and Weick, 1984; Davies, 1970; de Weerd-Nederhof, Pacitti, da Silva Gomes and Pearson, 2002; Glaser, 1986; Hackman and Morris, 1975; Weick, 1995; Rickards and Freedman, 1978; Glaser, 1986; Smith, 1989; Weick, 1995).



These key themes are seen to have the greatest impact on the problem, namely:

- **developing a shared cognition** which in this context refers more to a shared understanding through a common vocabulary, which is collectively developed, than the more precise definitions used by cognitive specialists such as Eden (2002)
- **developing team creativity** which relates to ensuring that the team is building on each others inputs to push the boundary between what is currently known by the team and what is unknown.
- **developing task relevant knowledge** relates to processes that focus the team on acquiring knowledge that is needed to further the task.
- clarifying the **team roles** relates to the need to ensure there is an interrelatedness in the efforts of the team, that while everyone is clear on their areas of responsibility there is clarity in the overlap of the domains of knowledge and that for example the marketing person and research person are understanding each others focus and hence are able to support each others efforts in parallel.
- The means by which the **tasks are tracked** relates to the practical project management element of ensuring everyone knows the information that impacts on their area of focus and that the collective process is managed.

### Aim

The aim of this study is to develop and test a process or framework to assist cross-functional, innovation teams in the process of managing task relevant knowledge (TRK).

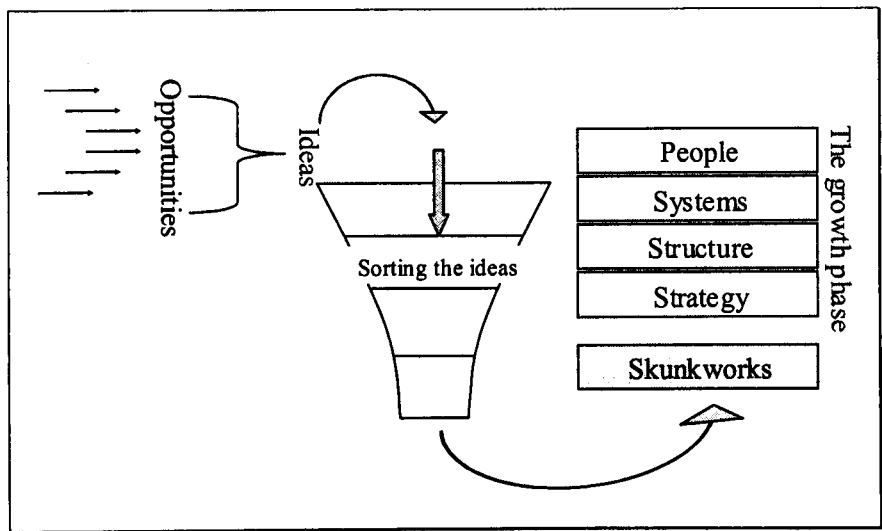
### **Focus of enquiry & Research context**

This aim is pursued through combining existing tried and tested blocks of knowledge such as cognitive mapping, knowledge management, nominal group technique, project management, and brainstorming processes, this approach to the framework development is described by Clark and Wheelwright, (1992), as an architectural innovation. The advantage to this approach is that if the building blocks of the framework are based on proven methods, the framework itself has an inferred credibility. Hence the focus of enquiry would involve seeking to express a combination of theory, practical experience and proven methods into the context of innovation teams.

The innovations that the teams work on have themselves different classifications such as radical innovation, incremental innovation and architectural innovation (Afuah, 2003). All the innovations undertaken by the teams in this study are themselves architectural in nature which means that the innovation requires accessing existing blocks of knowledge and weaving them together in such a way as to create an outcome that is different or innovative. This type of innovation is common (Henderson and Clark, 1990) and well suited to being tackled by teams with competencies that represent the building blocks of knowledge needed to develop the task, even if the path of development is ill-structured at the outset.

Innovation management is an important element of strategic management (Afuah, 2003). Majaro describes how projects move through distinct stages of development (Majaro, 1988), as detailed in Fig 1.1. These stages of innovation management can be classified as opportunity selection, idea generation, the screening of the ideas down to the specific idea that is to be commercialised, feasibility studies, the stage described as Skunkworks (in which the research is conducted), and the growth stages of the project which require more traditional management tools.

Fig. 1-1: The business context of the research



It is in this “Skunkworks” stage that the problem is characterised as ill-structured and complex, but as the development path proceeds, that the task relevant knowledge develops to the point where it can be process driven by traditional project management tools.

The type of innovation projects and the nature of the teams are described in detail in Chapter 4, but essentially involve innovative entrepreneurial teams, of four to seven members operating mostly in a complex technical environment.

### 1.3 *Thesis structure*

This thesis is presented in seven chapters as follows:

**Chapter 1:** introduces the problem and propositions.

**Chapter 2:** Reviews relevant literature, and identifies the five themes that have a strong influence on task relevant knowledge in the given context.

**Chapter 3:** describes the action research method used to develop iteratively a framework that has an impact on the key themes.

**Chapter 4:** reports findings in terms of the context of the projects researched.

**Chapter 5:** looks at both localised and generalised learning in each project, as well as how the framework was modified after each iteration.

**Chapter 6:** discusses the generalised theory in the form of the seven framework steps as well as the impact each step has on the key themes.

**Chapter 7:** presents the conclusion and considers issues of validity.

**Appendix:** A.1 Facilitators notes

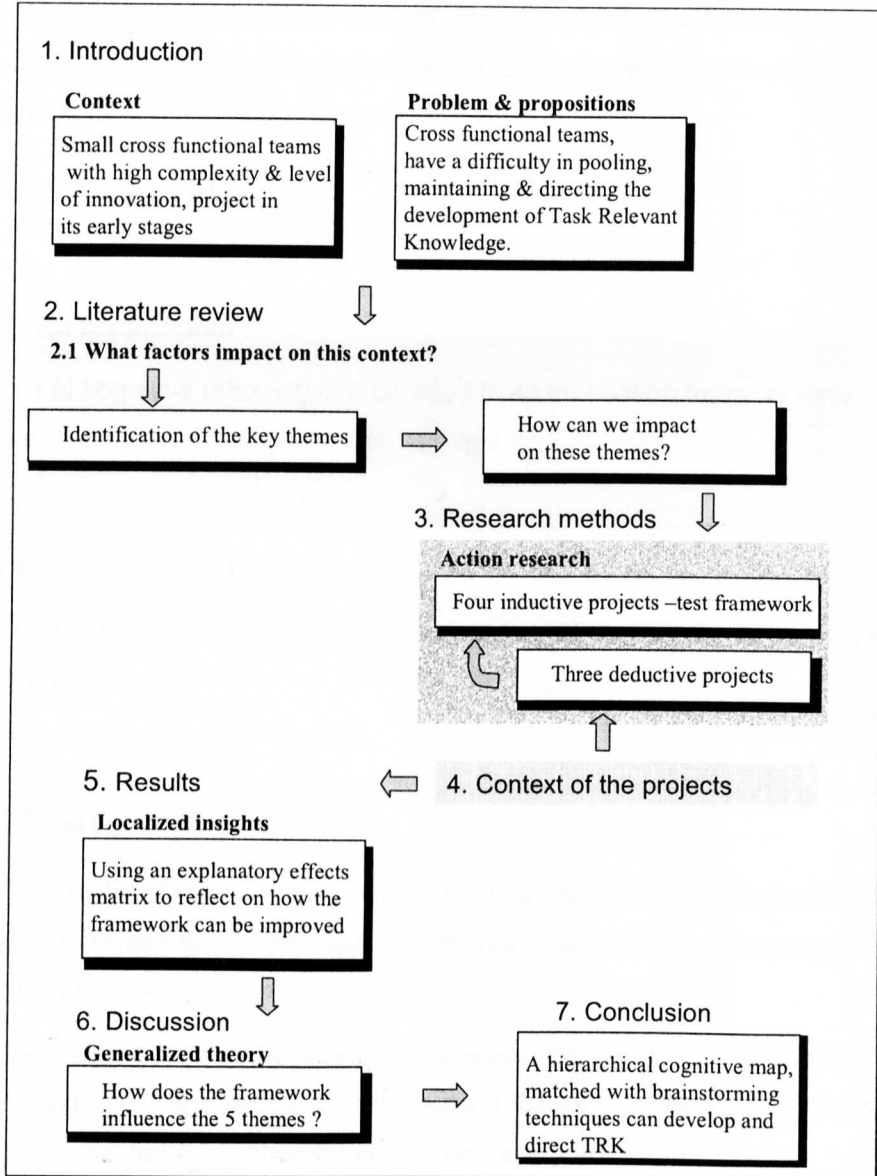
A.2 An example of a semi-structured interview

A.3 A glossary of terms.

A.4 A sample interview

The Salient elements within this thesis structure are detailed in Figure 1-2 below. This presents the research in a logical sequence which does not reflect the non-traditional nature of the research, but makes it easier to read when organised in this way.

Fig. 1-2: Thesis structure



### 1.4 Sub-problems

#### First sub-problem

The first sub-problem was to design a framework that can facilitate a shared understanding of the team's task relevant knowledge at any point in time.

### **Second sub-problem**

The second sub-problem was verifying the ability of the framework to direct the development of the team's task relevant knowledge to team members' satisfaction.

## **1.5 Propositions**

### **The first proposition**

A form of cognitive mapping can be used in an innovation team, to develop a shared cognition of a project's task relevant knowledge.

### **The second proposition**

The output from this mapping process can direct the growth of task relevant knowledge.

## **1.6 Assumptions**

- 1) The project objective developed by the team was assumed to be a valid and approved task or problem, which was closed-ended. The project in all cases was ill-structured in its nature.
- 2) For the purposes of the scope of this study, the focus is on innovation management of a radical or architectural nature only, as these forms of innovation have an inherently high level of uncertainty.
- 3) It was assumed that the individual and group aspect of team selection, types of roles that the members of the team played, while having an impact on the process, lay outside the focus of the research, as the teams were already formed at this stage of the research. Other models have been developed to normalise these effects through standard team staffing practices (such as the work done by Belbin (2000) on team composition).

These elements would have an impact on the research but given the context of the research, their effects would not be of primary focus.

- 4) The team charter was understood and agreed on by all the team members in all the cases under research.

### **1.6 Scope**

- 1) The research was limited to South African companies as the source of data, to which the author has easy access. This could have cultural biases in the design and use of the framework.
- 2) The framework derived was not intended as a replacement for innovation management systems or project management tools such as GANTT charts, but is rather to be used in a complementary capacity.
- 3) The framework was developed in the context of innovation management as development teams typically explore new ideas (territory) on a regular basis. It is in this area where development teams have the greatest need for the framework described. The framework does not necessarily have any validity in contexts other than innovation.
- 4) Clearly, many themes influencing innovation in teams are outside the scope of the key themes that the framework focuses on, and were not included in the scope of the framework. As a consequence, the framework is not a complete solution for managing innovation in teams over all stages of development, but will rather aim to have an impact on the ability of the team to develop task relevant knowledge in the early stages of the project.

## Chapter 2: Literature review

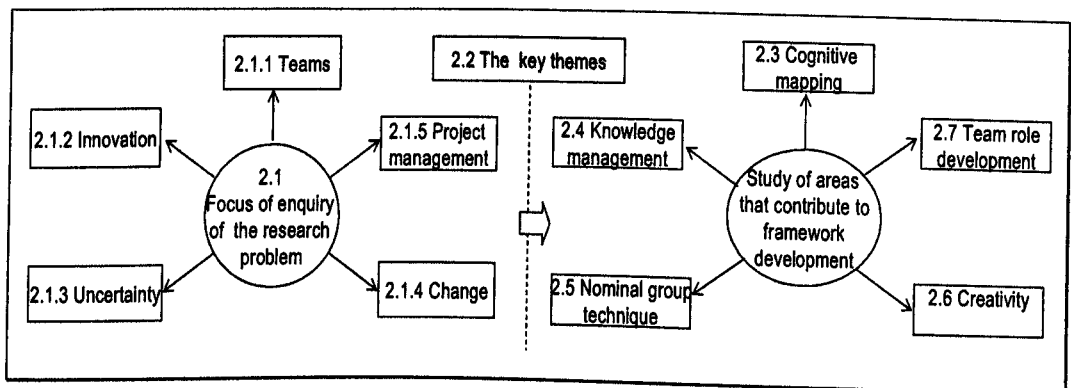
### 2.1 Location of the research problem

In order to correctly frame the research problem, it became clear that initial research was needed into team processes, innovation management, uncertainty, project management and change management. This would establish any gaps between existing literature and the needs of innovation teams in practice. This initial enquiry would then identify the key themes that the framework would have to impact on, in order to impact on the stated problem.

In order to positively influence the key themes the literature would then be reviewed to establish which existing blocks of knowledge could be woven together toward a framework that would develop a shared cognition and manage the development of task relevant knowledge. These blocks of knowledge that contribute toward this solution were found to be: cognitive mapping, creativity methods, knowledge management, nominal group technique, team roles and task tracking.

Hence the non-traditional more deductive approach to this chapter is structured in two parts as described in Fig 2.1 below.

Fig. 2-1: A mapping of the literature review chapter





### 2.1.1 Teams

#### Why teams?

Before we explore the themes that influence team effectiveness we must first ask the question, why use teams at all?

The vast body of literature and practice strongly supports the use of cross-functional teams for complex innovations. The collective team effort makes an essential contribution to the intentions, direction, effectiveness and thus the growth potential of the firm (Bird, 1988; Gersick, 1989; Afuah, 2003).

*“Team effort may be crucial at the start-up-stage, when firms need a variety of resources, but lack most of it. The impact of early team effort does not however limit the start-up-phase as the entrepreneur’s intentions fuel the direction of the firm and determine its size and growth potential”* (Vyakarnam, Jacobs and Handleberg, 1996,pg. 23), the collective team effort may make an essential contribution to the intentions and thus the growth potential of the firm.

#### The themes that influence team effectiveness

A review of the literature on team effectiveness shows a seemingly endless list of themes that have an impact on team effectiveness. Examples of these themes in no particular order are: leadership (Watson, 1995), structure and systems (Timmons, 1995), personality of members (Morris, 1989), member skills (Mohrman and Cohen, 1994), member attitudes, team morale (Bird, 1989), team co-operation and interdependence (Hackman, 1987), team cohesion, task vision and purpose (Vyakarnam and Jacobs, 1993), task boundaries (Levenhagen, Porac and Thomas, 1993), team diversity (Belbin, 2000), flexibility of team and structure, reward systems – individual and group, team and organisational structure (Campion, Medsker and Higgs, 1993), culture, autonomy of group, performance feedback, training and consultation, level of shared cognition, access to management, (Shea and Guzzo, 1987),

team resource access, technology, beliefs, creativity, group roles (Kamm and Nurick, 1993), group norms, political support, external integration, communication, and physical environment.

### How do these themes relate?

There are many models drawn both from the fields of organisational behaviour and organisational design which illustrate how the different themes which influence team effectiveness can be grouped to create categories, and how these categories relate.

The categorisation of themes, allows us to examine the nature of the relationships between the groupings through models already developed in literature. The purpose of this is to logically reduce the list of themes that influence team effectiveness by eliminating categories of themes that are not relevant to the research context. An in-depth critique of the models of managing team effectiveness is not the focus of the team literature, but rather to establish through this review the key themes influencing team effectiveness, in the research context.

### The Interaction Processes Model

This early but influential input-process-output model (Hackman et al., 1975) of group effectiveness presents an interesting categorisation of the themes.

Themes such as member skills, knowledge, motivation, power, and personality are grouped into an **individual level** category. Themes such as team structure, level of cohesiveness, and size are classed as a **group level** category. An **organisational level** category incorporates themes such as task characteristics, task process, reward structures, and environmental stress. The influence of these three categories is mediated by the interaction processes between these categories over the task duration which deliver the resultant output which is equivalent to the team's effectiveness. The authors

do not go on to explain how this interaction process mediates the efficiency of the group.

The relevance to the research is that clearly the individual and group level categories are not something that the framework could influence, as the context in which the framework operates is separate from the selection of the team. Hence individual and group level categories were ignored in the development of the framework. The framework could however be developed to have an influence on the organisational level category and hence themes that relate to this grouping were retained as possible influencing factors on team performance in the given context, and hence models looking at the organisational aspects of team behaviour were then explored.

### The Integrative Organisational Behaviour Model

The most empirically validated organisational behaviour model was proposed by Campion, Medsker and Higgs (1993). This model identifies the five categories listed below drawn from previous theories.

- The **job design** category speaks about the early stages of team design that influence the context to create motivated members of the team.
- The **interdependence** category (Shea et al., 1987) is described below.
- The **composition** category relates to the population of the team.
- The **process** category reflects elements such as means of workload sharing, communication, shared cognition and co-operation in the group.
- The **context** category considers the organisational context and resources to make the team effective.

The categories which have the greatest relevance to this study are the **process** and **interdependence** categories, as the framework looks to enable team effectiveness, after consideration of the other identified categories. The

research will hence focus on these two categories in developing an enabling framework.

The influence of the other categories on the team efficiency presents no problem in the research being undertaken, as frameworks to enhance team effectiveness have been developed that have relevance to that particular stage of development of the team. An example of a method in the "creating the necessary performance conditions" stage is the research undertaken by Belbin (2000), to develop methods to ensure the correct mix of personality types in a team and methods of clarifying team roles.

### **The interdependence category**

The authors Shea and Guzzo (1987) abandoned the input-process-output model so common in literature and suggested that task interdependence, outcome interdependence and potency, interrelate to determine team effectiveness. The task **interdependence** category refers to the degree of task-driven interaction among members. Outcome interdependence refers to the consequences shared by team members and potency refers to "the collective belief of a group that it can be effective" (Shea et al., 1987, pg. 335).

This model serves to highlight the importance of task interdependence to effective teams. The team is viewed not as a group of high performing individuals with specific sub-tasks within a larger task but rather people who are mutually interdependent and must continually share and challenge views on aspects of the task at hand. This view certainly has a rational basis, however if taken to the extreme can clearly lead to inefficient use of resources in a research team.

Task interdependencies only become evident after a shared task interpretation. Hence this approach to team effectiveness highlights the

importance of developing a shared cognition in a team to ensure task interdependencies are enabled.

### **The process category**

Different researchers (Corti and Lo Storto, 2000; Hackman and Kaplan, 1974; Gupta and Wileman, 1988; Huber, 1984; Campion et al., 1993; Morgenson, Aiman-Smith and Campion, 1997), have explored the process category (sometimes using different descriptors), with the most common themes relating to this process category being: environmental linkages, member interdependence, workload sharing, communication, shared cognition, problem solving, creativity, participative safety, flexible process structure, problem framing and co-operation in the group.

As a consequence, the next sections explore the processes in the context of the research: entrepreneurial teams in early stage ventures, working on innovative ill-structured problems needing to undergo rapid change.

As a consequence of the context of the team in this research, it is clear that certain themes will have greater or lesser influence on team performance. Not all the literature researched is presented to avoid repetition, but extra research into the process category was undertaken (Baybrooke and Lindblom, 1963; Clark et al., 1992; Corti and Lo Storto, 1997; Daft et al., 1984; Gersick and Hackman, 1990; Marples, 1961; Zwicky and Wilson, 1965; Harkerna, 2003; de Weerd-Nederhof et al., 2002; Huber, 1984; Brown and Eisenhardt, 1995; Davies, 1970; Senge, 1990; King and Anderson, 1995; Tanker, 1997; McAdam and McClelland, 2002), and, while different terminology is often used the themes can be distilled into those listed in Table 2.1.

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Table 2.1: The influence of themes on team effectiveness

Theme	Influence and reason for influence
Team composition	Low, team already formed on the basis of skills and personalities needed
Team purpose	Low, already clearly developed
Team accountability, and motivation	Low, in all teams there was high motivation and accountability / interrelatedness
The nature of the task	Low, all drawn from complex requirements in one industry
Duration of the task	All teams were project teams
Individual theme	Low, ability to influence teams already formed
Team social dynamics	Low influence. Team culture and climate do directly affect the motivation of team members, but assumed to be a pre-condition to proceeding with the task
<b>Problem solving</b>	<b>High influence as TRK is developed by problem solving processes</b>
<b>Business linkages</b>	<b>High influence as the need to develop task relevant knowledge rapidly could be enabled through effective business linkages</b>
<b>Creativity processes</b>	<b>High influence as there was a significant need to develop the task relevant knowledge creatively</b>
<b>Team communication – shared cognition</b>	<b>High influence due to early specialisation in roles needing high levels of shared cognition</b>
<b>Task tracking</b>	<b>High influence as the rapid development of task relevant knowledge needs processes to direct the teams resources</b>
<b>Developing TRK</b>	<b>High influence as in all teams, members were very new to the task</b>
<b>Team roles</b>	<b>High influence as no prior role in the team is defined in advance</b>

Table 2.1 shows the themes that will have a dominant influence on the team's performance. The themes that had a high influence were explored further with the exception of problem solving and business linkages, which were taken to be a subset of developing task relevant knowledge, thus from this table five dominant themes emerge: *developing a shared cognition, the development of task relevant knowledge, creativity, task tracking and the development of clear roles in the team.*

### 2.1.2 Innovation management

While the management of innovation is a relatively new field of study, there have evolved models of innovation that are designed to facilitate the process of managing innovation. These models will be reviewed to establish their contribution to the focus of enquiry.

Innovation is seen as a process where ideas are generated and transformed into implemented business products or services (McAdam et al., 2002).

Innovation teams are commonly linked to start-ups in high technology industries (Obermayer, 1980; Teach, Tarpey and Schwartz, 1986). It is argued that high technology industries require more skills than one individual is likely to have, necessitating that individuals combine their abilities in teams in order to start an organisation successfully. A few studies (De Carol and Lyons, 1979) have shown, however, that innovation teams occur across all industries.

### Models of innovation

There are many typologies of innovation processes are being managed by different models. Scozzi and Garavelli (2005) describe these typologies and the models that can be used to manage them under the heading below.

- **A *sequence* of tasks**

This aspect of innovation is well described in project management literature through flow charts, GANTT charts, and IDEF0's. (e.g. Grover and Kettinger, 1995; Presley, Sarkis and Liles, 2000). This is useful to an innovation project only once the team is clear what the tasks are. In the early stages of exploring the task the team does not have a fix on what is involved and are not able to describe the sequence of tasks. Once the tasks are clearly established then the innovation models that manage a sequence of tasks become useful. Towards the end of the frameworks utility it will integrate with models such as GANTT charts.

- A set of **decisions** that evolve over time

This aspect can be supported by modelling techniques based on decisions and states such as simulation models, decision trees, design rationale, analytical hierarchy processes, Petri net and state transition diagrams (Aalst and Hee, 1996; Marples, 1961). While these techniques are useful once it is clear what decisions need to be made, in the context of the research this is far from clear and hence decision related models have limited utility.

- A set of **political** processes

This includes models whose ontologies are concept-based such as cognitive maps, active-workflow models and speech interaction modelling (Kettinger, Teng and Guha, 1997). The context of needing to socialise the knowledge of the group, clearly fits the focus of enquiry and hence cognitive maps are a block of knowledge that has potential to contribute to the framework and will be research further in following sections.

- A set of **interpretative** processes

Teams are social constructions and as such models whose ontology's are concept-based such as cognitive maps and IDEF5 are suited for use (Grover et al., 1995). The same comment as above would apply.

- A set of **creative** processes

These include affinity diagramming, brainstorming, and the Dephi technique, which are used to grapple creatively on the edges of the knowledge domains of the team and hence fit well with the context and hence it is envisaged that the framework would include divergence techniques as described in the creativity literature.



From the list above of the models that are available, it is clear that each of the listed typologies addresses aspects of innovation management which have prominence at different points in the innovation cycle or addresses different themes within innovation processes. In the context the last three process types best fit and hence there is support from the literature on innovation for both brainstorming and cognitive mapping as blocks of literature to research to contribute to the framework.

Innovation could also be seen a process of reducing the uncertainty surrounding a problem by increasing the task relevant knowledge (Corti et al., 2000). It is this innovation research using uncertainty reduction techniques that prompted the researcher to include uncertainty into the focus of enquiry as described in the following section.

### **2.1.3 Uncertainty**

Reflecting on the authors experience in development teams, it seemed to be that human nature amongst a group of specialists leads the group to spend large chunks of time on re-explaining what everyone already knew as this was comfortable to them. It seemed that people were reluctant to speak about what they did not know. It was clear that this concept of uncertainty had to be researched further, to review the techniques that are used to manage uncertainty and push these innovation teams towards reducing the uncertainty involved in the innovation process.

#### **Definitions of uncertainty**

Uncertainty is different from risk in that risk is the result of probabilistic information (risk requires a certain level of predictability in order to assign a probability), whereas uncertainty results as a consequence of the increased variance between the knowledge domains of the team and the task (Dunkan, 1972).

In order to obtain a clearer view of uncertainty a typology is needed:

- incompleteness – ignorance of what can be known;
- indeterminacy – the unpredictability of future events;
- incommensurability – of ideas and measures used.

It is the “incompleteness” aspect of uncertainty that is the focus of this study, as this is the root of the development of TRK (hence, developing TRK is discussed further in this chapter). In project management literature this aspect of uncertainty is also called foreseeable uncertainty and suggests that the project team should increase the awareness of changes in the environment relative to the known criteria and continually motivate stakeholders to become more informed in these dimensions (De Meyer, Loch and Pich, 2002).

### **Methods for managing uncertainty**

As an innovative venture seeks to develop a better sense of the uncertainty surrounding the initiative there are several traditional techniques that have been used (Doctor, Newton and Pearson, 2000). These are listed below.

1. **The use of financial methods for risk analysis:** this includes a number of models and approaches such as the Capital Asset Pricing Model, option pricing, and discounted cash flow. (Higgins and Watts, 1986). These processes tend to focus on the risk dimension and would only have applicability once the risk can be adequately quantified and hence apply later on in the project lifecycle than this research focused on.
2. **Scenario planning:** this approach to managing uncertainty is to seek an outline of the project path under the different options to determine possible sets of actions. This approach again reflects the philosophy of

many of the financial modelling approaches such as Monte Carlo simulations (Hertz, 1964).

3. **Decision trees:** this well researched approach seeks to outline the project path, understand the probabilities of success along that path and assist in the development of project gates (Thomas, 1972). The focus of this approach is, as the name suggests, guides the decision-making of the project manager, and also is not focused on the incompleteness aspect of uncertainty. This technique would have utility only later on in the project life-cycle.
4. **Cognitive mapping:** this is used to reduce framing bias and allow for a deeper shared exploration of the knowledge needed for effective uncertainty reduction (Hodgkinson, Bown and Maule, 1999). Evidence from research by Swan (1997, pg. 196) seems to indicate that cognitive mapping might potentially be developed into a tool for “promoting decision maker’s understandings of potential problems and design choices and encourage negotiation in the innovation decision process”.

It is clear from this overview of uncertainty that, for this research cognitive mapping as a means of developing the group’s knowledge again raises its potential as an approach. The other techniques to managing uncertainty seem to ignore the early stage of the project, with no particular technique or approach being identified that specifically deals with ill-structured complex problems.

Cognitive mapping seemed to a useful area to explore as its fluidity allowed for rapid evolution which was important in environments of rapid change and high uncertainty. This fluidity exists as the approach allows for the use of transitional objects that enable the flexible movement with the direction of development so as not to lock into a particular way of seeing the task. The balance between firmness and flexibility is emphasised as a key feature of successful frameworks for managing innovation and environments of high uncertainty (Tatikonda and Rosenthal, 2000).

Reflecting on the literature and the reluctance of the team to move into uncertain ground, it seemed that Kelly's personal construct theory (1955), could be useful in that it is human nature to be better able to express what is known through considering what is unknown. This strange twist of logic provided the insight needed for integrating uncertainty as a driver for developing the task relevant knowledge and building a map. The question that would be used to seed and develop the map would be "what are you uncertain about in your knowledge of the task". By introducing the word uncertainty rather than focusing on certainty the team is always pushed towards the gaps in knowledge domains.

### **2.1.4 Change**

Change has always been a fundamental part of business, but major change requiring many people to become good at behaviours and tasks of which they have no present knowledge, is becoming an important business competency in today's business world (Katzenbach and Smith, 1993). This competency is especially true in the business context of innovative entrepreneurial start-ups with the research on uncertainty again highlighting the need to be able to manage change processes as the uncertainty rapidly reduces in the project, and so it was to this area of literature the research turned to next.

#### **Early team change management: process models**

Cartwright (1951) was one of the earlier proponents of change through teams. He proposed that teams could be used to influence individual behaviour if the team had a good cohesiveness, and if the change effort was aligned to the group's purpose. The themes he describes which influence the capacity of a team for change are: a shared understanding of the need for the change, the structure for change and the consequences of change. House, (1967) developed these tenets into team themes necessary for change that are

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similar to the themes described in the integrative organisational behaviour models, namely: participant characteristics, learning effort, leadership climate, organisational climate, and organisational culture.

The early change theories highlight the following important themes that must be considered when implementing team change:

- social theme – team norms, coherence, climate and culture;
- individual theme – skills, aptitude for change, and motivation;
- organisational theme – communication, structures, resources, systems, networks and support.

These themes are congruent with the themes described in the team efficiency literature; however, the focus of change in this research is how to manage high rates of change in teams where the inertia is low as a consequence of little or no prior operations in the area of the task and where even though the problem is ill-structured, it is not ill-defined, so the teams have a clear goal, with a definitive endpoint. This context hence excludes the emergent change models.

### Team change process frameworks

Change in the context of the research is driven by a gap between the existing current state of knowledge and the desired future state of knowledge. All the efforts of the team are focused on problem solving activity that reduces this gap (Wagner, 1993).

The team change processes from an organisational design perspective describe a number of clear stages required to close the gap described above. The research of Morgenson, Aiman-Smith and Campion (1997), summarises the earlier change implementation literature into a generic set of organisational design steps in a planned change model as follows: *discontent, diagnosis, data feedback and goal establishment, implementation, evaluation and stabilisation*.

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The stages prior to implementation are, as discussed, outside the ambit of the research. The *stabilisation stage* refers to the importance of communicating the change outside the boundaries of the team and the re-habitualisation of the new processes into the organisation. This aspect is important when the team is operating in the context of a larger organisation, but the framework is being evolved for small innovative start-ups and, as a consequence, this theme was not taken into consideration in the design of the framework. Hence only the *implementation, evaluation and feedback* stages have relevance in the context of this research.

The change models reviewed thus far also tended to provide broad high level processes and do not describe the detail of the technique so as to contribute to the framework. Morgenson et al., (1997) however does discuss themes that have an influence in the *implementation stage* as listed below.

- Establish clear reward systems that foster team cohesion.
- Plan for the required training and organisational support systems.
- Sub-task interdependence –identify clusters of concepts related to the implementation to allow for the matching of these tasks to the member with the best skills.
- Set mechanisms for regular communication between team members.
- An unambiguous understanding of the accountabilities for subtasks in the team must be developed.
- Establish a mechanism for monitoring these accountabilities that is as agile as is required by the rate of change of the sub-tasks.

The *evaluation and feedback* stages were described as vital to ensure the team maintains a shared knowledge pool and can use team synergies to complement the findings in the implementation phase, maximise the shared understanding and if necessary redesign the team's work. Sub-task interdependence was highlighted across the research as an important variable to ensure the greatest team effectiveness. These are interesting factors to

take into account during the design of the framework but again the change management literature did not describe the specific techniques of achieving these objectives.

Kotter and Cohen (2002, pg. 37) studied the characteristics of the teams that guide change processes and suggested these themes being as important to change teams:

- ability to develop the relevant knowledge;
- a clear task understanding and objectives;
- team cohesion;
- team composed of the right mix of skills and authority;
- team roles to be defined early in the change process;
- high levels of trust in evidence in the team.

In summary, the research processes used in change management reinforce the importance of following themes also identified in team theory that influence team efficiency in the context of this research:

- a clear task understanding;
- the importance of a shared cognition, which creates a clear means of communication between the team members and outside stakeholders;
- sub task interdependence ;
- the ability to develop groupings of subtasks that can be allocated to the best team member for resolution with a suitably agile means of monitoring.

### **2.1.5 Project management**

The research conducted thus-far highlighted project management as an area that could assist in establishing the focus of enquiry. In order to understand if project management could contribute to the framework, or to address the interface, the project management literature was reviewed.

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Project managers in the past have been faced with the tracking of tasks in the context described. The project manager's response to these challenges has traditionally been the Work Breakdown structure. This is a hierarchical list or diagram representing all the tasks that must be finished to complete the project.

This deliverable-orientated grouping of project elements (the work breakdown structure or W.B.S) is created in five steps (Knutson, 2001).

1. Restate the project objective.
2. Decompose the project into major elements of work (level one categories).
3. Decompose the level one work into its more detailed sub-tasks.
4. Identify a task owner and deliverable for each task at the lowest level of the work breakdown structure.
5. Write a task description for each task.

While these steps are described in detail in the Project Management Body Of Knowledge (Duncan, 1996), the mechanism for achieving a shared cognition for each of the tasks and subtasks was not described, but it was found that the clear events at the bottom of the ladder in the cognitive map could be drawn easily into a traditional GANTT chart.

### **Implications for the research**

Any new framework being developed, would gain easier acceptance and usage if it fits to a degree into the existing tools and frameworks that are used in practice. Hence the framework being developed should fit into the work breakdown structure approach and complement it, rather than seek to replace it. The ethos embedded in the work breakdown structure is: to describe the task in a single verb, break the task into its subcomponents and assign ownership at the lowest level of the hierarchy. The framework being



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developed should follow the same concept of concept laddering and be able to interface with the described project management techniques. The point at which the framework should phase out and the factors that influence this point is a subject for further research, but will interface with a GANTT chart.

### **Outcomes of the initial research**

Based on these five areas of enquiry, the areas of cognitive mapping, knowledge management, creativity and team role development were highlighted as having potential to contribute to the framework. The review of these areas also supported the impression that no complete framework existed in these areas that could develop the stated problem. This literature review did establish that the frameworks effectiveness could be monitored through impacting on the five key themes of: shared cognition, creativity, developing task relevant knowledge, task role development and task tracking. The question of what techniques are used in literature to impact on these five themes formed the focus of the next section of the literature review.

### 2.2 Researching the key themes

The next section of the literature review focuses on exploring each of the key themes in turn. The concept of using architectural innovation in developing the framework was key to the approach (Henderson et al., 1990).

Architectural innovation translated into this context involves using existing proven methods of addressing individually each of the key themes, and trusting that a compilation of these methods would constitute the building blocks toward a first pass framework that has a rigorous grounding and is sufficiently developed to be able to be used on a project with an action research approach.

Based on the literature reviewed to this stage the concept of exploring how the identified themes could be inter-related and what literature could be accessed that could assist in enabling each of the key themes. It was suggested as a starting point that the key themes could be inter-related in the following way to establish a rudimentary framework:

1. the team's development of a shared cognition  
*(establish collectively what do we know?);*
2. the teams creative processes  
*(a creative exploration of what we don't know that we need to know);*
3. the team's development of their task relevant knowledge  
*(how do we convert what we don't know into what is known?);*
4. the team's role development.  
*(who's doing what in this conversion process?);*
5. the team's tracking of the task  
*(maintaining a shared cognition as the task develops).*

## **2.3 Cognitive mapping**

### **2.3.1 What is a shared cognition?**

Teams that are effective have a natural tendency to review events, correct errors, discuss strategies, and plan for future events. Team members can correct their team cognition, attitudes, and behaviours without outside intervention. (Blickensderfer, Cannon-Bowers and Salas, 1997)

This capacity depends on the communicative competence of the team and has been described as social capital and results from a strong shared mental model (Nielsen, 2003). Hence the communicative competence of a team is evidenced through a shared mental model which is the focus of this section.

Researchers have hypothesised that humans interact effectively with their environment by organising knowledge into meaningful patterns called mental models. Rouse and Morris (1986) define mental models as mechanisms which allow humans to generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states.

An extension of mental model theory has been a theory of shared mental models. A shared mental model is a shared set of abstract concepts for comprehension of understanding. This shared understanding can be visually depicted through the application of cognitive mapping (Spicer, 1998). The level of shared cognition has been suggested as a theme influencing team effectiveness in the case of complex cross-functional teams.

There is a potential issue arising from cognitive mapping literature about how one moves from individual cognition to group cognition, for example by aggregation of individual maps. For the research it is accepted that innovation

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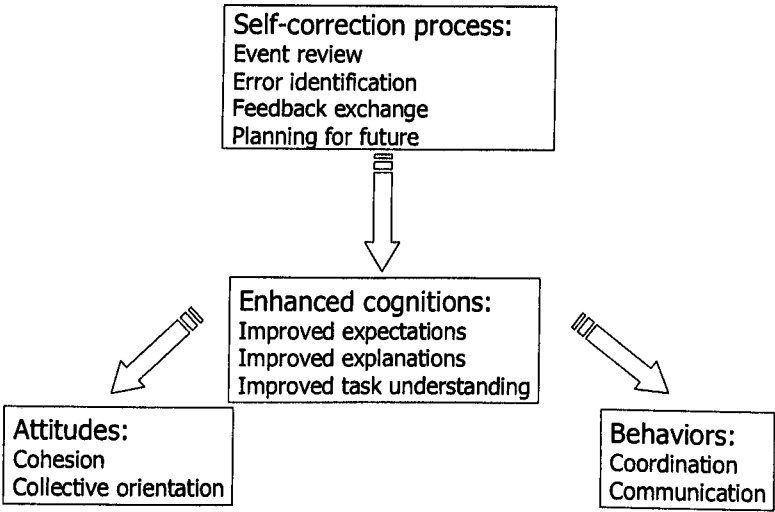
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teams are naturally operating in a group due to the nature of the objectives of the action research, and hence there is a nomothetic tendency due to the very nature of the project. A shared cognition in this context revolves more around developing shared vocabulary and process around the key ideas and issues that drive the project. There is no attempt to attribute cognition to the team, and there is hence not a need to explore the legitimacy of reification (Eden and Ackerman, 1992).

### Achieving a 'shared cognition' in a team

The processes needed for effective self-correction in teams can be depicted in Fig. 2.2.

Fig. 2-2: A process of shared cognition



Source: Blickensderfer et al., (1997, pp. 268)

Some researchers identify shared cognition as being evident in a shared set of expectations and shared explanations (Cream, Eggemeier and Klein, 1978; Vreuls and Obermayer, 1985 ). Shared expectations refer to a common understanding of the team's tasks and demands and shared explanations refer to a team's logic as to why an event occurred. It was postulated by

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Cannon-Bowers, Salas and Converse (1993) that shared expectations are a product of shared explanations. This would mean that, in exploring qualitatively whether a team has a shared cognition, the researcher should be asking questions that establish whether the team has a convergent view of the important ideas in the task over the entire path of its development. This could be easily explored in semi-structured interviews through comparisons of individual responses to task specific questions. The view of Blickensderfer et al., (1997) cautions us with views of Vroom expressed by other research such as that of Vroom (1964) which revolve around not ignoring the effects of mimicry without real shared understanding which can be driven by team dynamics such as plays for power.

It is not sufficient to agree that team performance can be influenced by the degree of shared cognition which flows from a shared set of explanations and expectations (common vocabulary), but rather to explore how to achieve higher levels of shared cognition. It is that question that is considered. The idea of using a visual mapping technique to capture what is known by the team was birthed from the researchers exposure to simple "mind mapping" tools commercialised by Tony Buzan (2001).

The question of whether mapping had any utility into the focus of enquiry was explored through the essential uses of maps (Huff and Jenkins 2002).

1. Maps can connect and organise dispersed organisational knowledge.
2. Maps can facilitate organisational activities by simplifying inevitably complex domains.
3. Maps have the capacity to represent knowledge at various levels of abstraction.
4. Maps can surface and organise concepts and relationships that are normally taken for granted.
5. Maps can facilitate communication in group settings and help aggregate opinions within a group
6. Maps have the capacity not only to catalogue but generate knowledge.

All six uses fit to some degree into the requirements in the context of the research and so based on this description mapping was thought to be a technique that could possibly contribute to the building blocks of the framework.

### 2.3.2 A mapping typology

A spatial mapping of named concepts placing them into relationships has been widely adopted in organisational behaviour. This visual mapping can be likened to a geographical map that can help to act as a repository and communicator of knowledge. The following typology of maps has been used in literature.

- 1) What the map is attempting to represent: e.g. mind mapping, causal mapping, and cognitive mapping? Hence the map can for example represent salient concepts, or represent cause and effect relationships.
- 2) What is the mapping analysis technique used and its method of elicitation? These can be best described through an idiographic versus nomothetic classification.

These two typologies will be used to explore the utility of cognitive mapping in the framework under development

#### **Mapping typologies: representation (mind, causal, and cognitive mapping)**

- 1) **Mind mapping**, popularised by Tony Buzan (2001) is an approach that has a central issue or task as a starting point and ideas that relate in some way to that central issue radiating out from it. Subordinate relationships are indicated in increasing detail as the length of the chain increases. This

approach is popularist, simple and was originally developed to facilitate effective note-taking, and knowledge representation.

By reducing a large quantity of data into groups of key words, these groups serve to act as the basis of an association with all the knowledge relating to that grouping or tree. Colour and images are sometimes used to identify and retain concept trees, and the “rules” that govern the structure of the map are left open to fit the needs of the context or the user. An example of a mind map is shown in fig 2.3 below.

This approach had two points of interest to the research, namely a visual representation of groups of key words could be useful in establishing a common vocabulary in the team as well as providing some common understanding of the relationships between groups of words. This then clearly provided a platform for further research into other more developed forms of socio-cognitive maps.

**2) Causal mapping** is an approach to describing the objective hierarchical causality between concepts. Cause Maps are graphical representations of the relationships between concepts and give one a sense of the overall structure of the whole set of portrayed assertions. Researchers with different conventions have developed various methods of causal mapping. However, certain characteristics can be drawn from them.

- They are often characterised by a hierarchical structure (Eden et al., 1992).
- They can often exhibit circularity (Bougon, Baird, Komocar and Ross, 1990).
- A concept with many arrows radiating from it would be taken to have a high level of richness and is often described as cognitively central (Eden et al., 1992).
- The ratio of the tails to nodes gives a broad indication of the relative flatness of the structure, which gives an idea of the depth of the causal arguments (Eden et al., 1992).
- The evolution of clusters gives an overall sense of the possibility for categorisation of areas of the map (Eden et al., 1992).

Hence, any effective form of causal mapping would tend to reflect some of these characteristics. Causal mapping while used generally in management research has philosophical complexities raised by the concept of causality in recent years (Swan, 1997). In practice during the action research phase of the research the ill-considered use of causal arrows led to “spaghetti maps” which were more confusing than enlightening in some aspects and so the causality between concepts was played down in future mappings. The concept of the evolution of clusters towards the categorisation of ideas was retained from this section of the research as it seemed worth exploring as a tool to simplify and socialise the ideas in the map.



It would seem to use causality as a driver for the development of the map has its limitations in the context of the research, as causality is difficult to assert due to the high levels of uncertainty that surround the project. Uncertainty itself might be a better driver as described later in the literature review.

**3) Cognitive mapping** is a way of depicting how concepts relate for a particular person or group. Many causal maps claim to be a form of cognitive mapping, but most, with the exception of Kelly (1955), are far from a model of cognition. Eden et al., (1992) regards the ability of a map to be a model of cognition, to be dependent on both the adequacy of the cognitive theory and the method of eliciting cognition.

The cognitive maps used in the developed framework are not models of cognition but rather transient objects that facilitate dialogue. For a time these maps might have some relationship to the internal psychological schema of the group or individual, but no attempt is made to force or facilitate this relationship. So while cognitive mapping had a clear fit with the research, there was a need to clarify the basis of elicitation and analysis of the map.

### **2.3.3 Mapping typology: map types and techniques of elicitation**

Approaches to maps can be classified as idiographic or nomothetic in design. This classification refers to either the elicitation of individual's ideas, which are then aggregated (idiographic), or developing a local theory which reflects the shared understanding and results as a product of complex team development processes (nomothetic).

Principally idiographic approaches will be explored in this section as this fitted well into the context of the research, as innovation teams in their very nature tend to develop a view based on individual team members' views and evolve this view through team processes. Methods of eliciting a collective cognitive

map from ideographic data, hinge upon obtaining a group consensus as to the constructs, three such techniques include:

1. building an average map from individual maps (Wieck and Bougon, 1986; Bougon, 1992);
2. a composite of individual maps (Wieck et al., 1986);
3. using discussion methods and processes to build a group map (Nelson and Matthews, 1991).

Langfield-Smith (1992) suggests that method three above is the most useful, as group discussion yields a group map that is more than the common content of the individual maps. This is not supported by Eden et al. (1992), who suggests that one-to-one interviews are the best approach, with the second best being group sessions using well designed elicitation techniques (Eden et al., 1992).

However it is recognised that the nature of these innovative projects lend themselves to group discussion, hence the last approach that of “discussion methods” is the preferred approach for the framework.

Eden does support the approach favoured for this research if viewing the group map is a *“visual interactive model, acting as a form of transitional object that encourages dialogues”*. The group discussion method suffers from the effects of audience and is hence mediated by the need of the participants for social desirability. For this reason techniques such as nominal group technique will be incorporated into the framework to retain an ideographic basis but using a group discussion method to aggregate. The group discussion method essentially elicits all the ideographic data and uses grouping and hierarchical laddering techniques to facilitated consensus toward comparing meaning, clustering, retaining and categorising of the concepts.

### **Mapping methods.**

There are many different approaches to developing a cognitive map such as: repertory grid technique, fixed grid technique, visual card sort technique, oval technique, the self-Q technique, the SODA approach, matrix multiplication techniques, semiotic techniques, and content analysis. All the techniques which use documented archival data are ignored as they are not suitable to the context of the research and only direct elicitation methods were considered. No attempt will be made to describe all of these direct elicitation methods in detail, but components of the different techniques that have relevance to the research problem are explored. The literature that details these techniques was reviewed in an attempt to develop a mapping technique that could form the starting point for the framework. The critique of the different approaches below describes the characteristics of these techniques and borrows components within each of them to develop a specific approach that would best suit the context.

### **Kelly's repertory grids**

This approach is built on a philosophy of constructive alternativism, whereby it is assumed that people's present interpretations of the universe are subject to revision or replacement. The method uses a role construct repertory test to elicit a representative sample of those constructs upon which an individual customarily relies to interpret and predict the behaviour of the significant people in his or her life, and to assess the way in which he / she relates these constructs to one another. This technique is essentially idiographic in nature as it leads to the discovery of the unique pattern of relationships among several constructs of a given person through asking in what way two elements are alike and hence different from a third.

Kelly's (1955) repertory grid technique was not directly followed in this research as this method, while the best validated of the cognitive methods, it is better suited to working on individuals rather than a team's cognition. Kelly's

method is ideal at eliciting constructs of individuals at a point in time, but his technique is not designed for easy mapping of the evolution of these constructs over time.

### **Self-Q technique**

In this approach, the central task once posed can be used as a starting point for the self-Q technique which was developed by Bougon (1983), whereby the people ask themselves questions surrounding the task to elicit constructs that can be used to start building a group map.

This approach appears to achieve an interesting balance in the ideographic vs. nomothetic debate. It is useful to have the task in the centre of the page around which the discussion can be focused and this was adopted for the framework. The seeding of questions to elicit constructs is useful as an approach to start to populate the map. What was extracted from the uncertainty literature, was to use the question of "What about the task are you uncertain of", and incorporated into the self-Q technique to build a useful set of shared vocabulary, as this question might force people to push the boundaries of what they do or don't know as it relates to the task. These approaches were taken as a starting point in the framework.

### **The Oval Mapping technique**

The Oval Mapping technique which is used in the context of strategy encourages an action bias to group cognition and involves the interesting features below (Eden et al., 2002):

- The group interactively writes up concepts on oval pieces of paper places them on a wall in clusters with inter and intra clusters evolving. The participant is encouraged to use the evolving map as a basis for further thoughts.

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- The public procedure allows participants to change their mind as their rationale is viewed in the context of the alternative viewpoints. This encourages creativity through the ability to see other points of view.
- This mapping process is a means of facilitating conversation in such a way as to amplify emotional and intellectual commitment.

These characteristics identify with the need for creativity and commitment in the framework being developed. The incorporation of elements of divergence and using concepts which were offered to seed to further group discussion was seen to be useful to the research. This was done in the Oval Mapping technique, through evolving clusters and regrouping around a cognitively central construct. Hence the outlook toward a first pass framework at this stage involved putting the task at the centre of the page and using some driving question to develop concepts and then using the clustering and re-aggregation processes to enable creativity.

Hence it was on the basis of these two techniques (Self Q and oval mapping) that the fundamentals of a framework started to form. The framework would, have the task in the centre of the page, use uncertainty as a question to populate concepts, capture these on ovals and use the grouping and cluster technique to get some sense of how the concepts relate. The updating and management of the maps was still unclear, and while a starting point to the framework was established the process to manage the progression of the maps over time was also unclear. The focus of the balance of this section will be on the approaches to developing and managing cognitive maps.

### 2.3.4 Managing cognitive maps

Fiol and Huff (1992, pg. 273) argue, that to be any reasonable use cognitive maps should be *"sense-making tools that can generate inputs to a continuing stream of decisions"*. This introduces a component of re-mapping and un-mapping that needs to be explored. How will the map effectively represent the cognition of the group over time as the views change with new information

and insights coming to light? Clearly artefacts will appear in a longitudinal study, and seem to be mostly managed in the different mapping techniques by re-mapping the map each time that the team re-examines the groups shared cognition. This approach would be suitable to the framework being developed as the intent is both to develop a shared vocabulary amongst the team and to maintain that as new task relevant knowledge is surfaced.

### **2.3.5 Implications for the research**

It should be clear from the approach to the research on cognitive mapping that the author has tried to steer clear of the need to assert a nomothetic outcome (Daniels and Johnson, 2002), and has designed the research approach in such a way that ideographic methods are acceptable to achieve the objectives of the research.

The author has followed the connectionist school of cognitive theory and has developed a framework that does not restrict the participants to predefined map dimensions. Thus the map will clearly be context-dependent and allows the participants the freedom to define their own constructs in an unstructured format (which was not the case in the early version of the framework).

The literature review thus far can be used as building blocks (architectural knowledge development), that at this stage exhibit the following features.

1. A hierarchical representation of the uncertainties remaining in the task will be used.
2. The mapping will branch out from the description of the core task in the centre of the paper.
3. The mapping will endeavour to capture a shared sense of the meaning behind each of the descriptors through a process of re-aggregation to assist in the development of potent concepts, and will use uncertainty as a key developer of the concepts.

The process of developing the knowledge relevant to the task in the intervening periods between the group meetings was a potential weak area in the above approach and without moving to the area of knowledge management the focus for the next stage of the literature review.

### **2.4 Knowledge management processes – developing TRK**

In the context of this research the teams are undertaking a project of which many of the team members have little prior knowledge and consequently they are going through a steep learning curve of developing the team's task relevant knowledge. The knowledge development occurs under the need to solve a problem (defined by a gap in the present and desired state of knowledge). In an organisation, routines for solving problems exist inside the heads of individuals or are codified in the form of operating procedures or manuals. If individuals or groups of individuals are confronted with an unfamiliar path between end states, then the problem is an ill-structured problem, the solving of which requires creative responses (Argyris and Schön, 1978).

McCampbell, Clare, and Glitters (1999), maintain that in an economy of uncertainty, the only source of competitive advantage is knowledge. They argue that, the new business environment is characterised by radical and continuous change, which requires team members to anticipate changes and carry out creation and action on new tasks. In simple terms if one applies knowledge to tasks one already knows how to do, one calls it productivity, but if one applies knowledge to tasks that are new and different to us, one calls it innovation, and so knowledge management is an antecedent to the innovation process (Drucker, 1999; Darroch, 2002).

### **2.4.1 Knowledge typologies**

Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates from, and is applied in, the minds of the “knowers”. In organisations, it often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices, and norms. Knowledge does, however, have a typology.

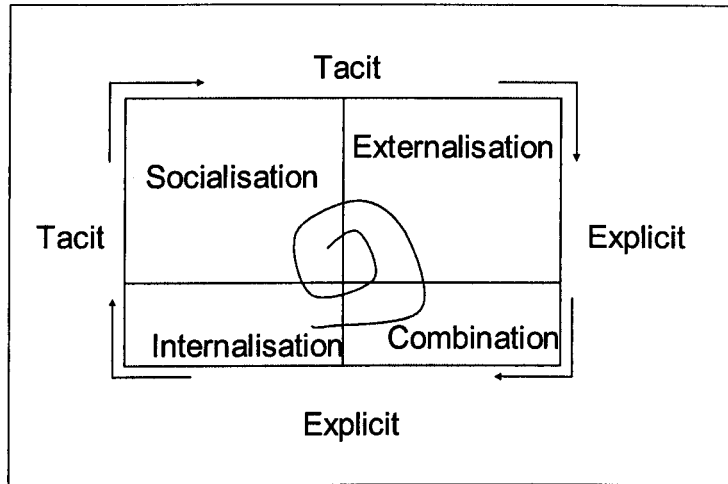
#### **Tacit and explicit knowledge**

Tacit knowledge is un-coded, non-verbalised knowledge embedded in the mind of the knower and is acquired through personal experience. Explicit knowledge is knowledge which can be stored in systems and processes and hence is more easily transferred (Afuah, 2003).

Tacit and explicit knowledge have a dynamic relationship as explained below. (Nonaka, 1999) proposes four modes of knowledge conversion: from tacit knowledge to tacit knowledge, from explicit knowledge to explicit knowledge, from tacit to explicit, and from explicit to tacit. In the first mode, tacit to tacit, knowledge can be converted through sharing and interaction between individuals. The key to tacit knowledge is experience, since it is difficult for humans to convey or explain tacit knowledge. Huff and Jenkins (2002) suggest that cognitive mapping can be used to make more explicit the tacit knowledge in an organisation. The second mode of knowledge conversion is explicit to explicit, and involves social interaction to configure existing information through sorting, categorising, adding, and re-contextualising explicit knowledge. The third and fourth modes expand over time and through a process of mutual interaction between individuals.



**Fig. 2-4: Knowledge development**



Source: Nonaka (1999,pg. 241)

Two main areas of task relevant knowledge are the sharing or pooling of existing knowledge and the creation of new knowledge.

Pooling of knowledge in this context refers predominantly to explicit knowledge, which is explored as a separate theme called developing a shared cognition. The creation of new knowledge occurs through the insights resulting from the pooling process and from interacting with other sources of knowledge outside the team, which might be internal or external to the company itself. It is the processes leading to knowledge creation that are explored in this next section.

### **2.4.2 The relationship between knowledge, uncertainty and ambiguity**

In highly complex situations the team will modify their assumptions adopting new mental categories to give meaning to and interpret the problem (Corti et al., 2000). This constructionist view of knowledge (knowledge being dependent on the individuals in the organisation) would hold that organisational knowledge is the result of the social interaction between individuals in the organisation, and is generated through the targeted effort of

these individuals to reduce the ambiguity (several interpretations) or uncertainty (variance between the mastery of information and knowledge domains), in the problem (Sutherland, 1977).

This ambiguity is reduced through problem solving, exploring new cause effect linkages, deconstruction and reclassification of different pieces of information. The issue of uncertainty in a problem is underpinned by a lack of information relevant to the problem which encourages participants to access external networks of information in order to reduce this uncertainty which has the effect of increasing the ambiguity (Corti et al., 2000).

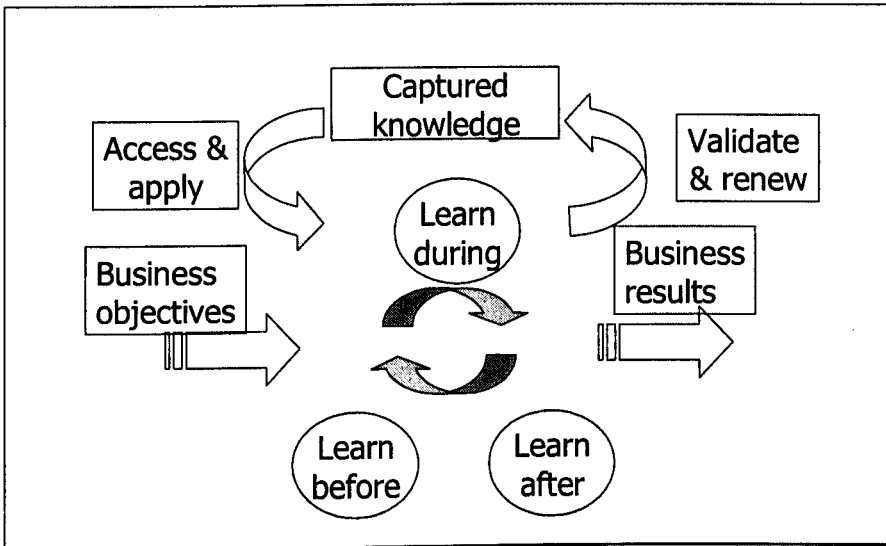
Any process that facilitates the reduction of ambiguity and uncertainty to build TRK would achieve this through the described ***information gathering or problem solving, exploring new cause effect linkages, deconstruction and reclassification behaviour***. The implications for the research are to focus the cognitive mapping technique around these uncertainty and ambiguity reduction behaviours.

### 2.4.3 Methods of managing a team's knowledge

#### Collison's BP model

A common element throughout the knowledge management literature is the need to make the team more aware of what they do not know rather than what they need to know. Much of the knowledge management literature (Collison et al., 2001;pg. 29) refers to this as moving from unconscious incompetence to conscious incompetence which obviously then creates a platform to move to conscious competence.

**Fig. 2-5: Methods to manage a team's knowledge: a KM framework**



Source: Collison et al., (2001, pg. 28)

This model which originated in British Petroleum (BP) was developed primarily to handle complex tasks of long duration where there is some prior task relevant knowledge and so does not perfectly fit the research context, but had some interesting steps. Collison et al., (2001), describes the steps to be taken to develop the task relevant knowledge which involve a collection of existing knowledge from sources before action, a group pooling process during learning and a post-learning distillation.

The process is started by asking a simple question to develop the task objectives and to initiate the knowledge sharing dialogue. Different responses are obtained to a simple question, such as “what is the key issue being faced?” From the insights in the literature review to this point, the obvious question if using the first pass framework is “what is the task”

This is a useful starting point in a process for developing a shared sense of the task, as a discussion around a dimension relating to the task begins to

develop a pool of raw data and a shared sense of how the team already views the task. This process should lead to a clear shared sense of what the business, project or task objective is.

Collison et al. (2001) use the following process then to facilitate the development of the team's shared cognition.

### **1. Learning before (learning from your peers)**

This philosophy can be observed across knowledge management literature, that "someone else has already done it". Often in innovation terms this is described as architectural innovation, where knowledge builds up in silos and by exploring these different blocks of knowledge and bringing them together one is often able to develop an innovative solution and approach (Clark et al., 1992; Kuczmarski, 1996).

The steps described by Collison et al.(2001) in order to learn from ones peers are: communicate the purpose which must be clear, share the plan and ask who has already encountered such a problem, and invite the pool of possible sources of knowledge to a meeting for their input.

This process ensures strong linkages between the team and its environment, and ensures that the team quickly elicits all the existing knowledge relevant to the task. The relevance of this stage to the research is that the framework must include in advance a stage where the information that could be relevant to the task should be collected and shared amongst the team members to ensure that the nature of the task is well understood. Then at the first meeting, the nature of the task must be clarified and the information studied in advance must be discussed and clarified amongst the team. The broad areas in which the task relevant knowledge is weak must be identified and allocated to

the most appropriate team member to go and research to “learn for the peers” internal and external to the company.

### **2. Learning while doing (time to reflect)**

The next stage of the model ensures that the team shares the learnings of the individual members at regular intervals during the learning process, which involves: Holding an “after action reflection” (AAR) while the participants’ memories are fresh, in the right climate, asking what was supposed to happen and what actually happened? Find a way of recording the key points. The relevance to the research is to ensure regular update meetings are held to update the map.

### **3. Learning after doing**

This involves the following steps:

1. Call a meeting with the relevant people.
2. Appoint a facilitator.
3. Revisit the objectives and deliverables.
4. What went well and why, and what could have gone better?
5. Record the meeting.

These steps have potential to contribute to this action research and imply that the learning before, during and after doing are complemented by processes to validate the information and integrate it into the knowledge base of the organisation. This integration requirement is not relevant to the context of this research, as in most cases the start-up team is the business. While there are useful elements in these processes for the framework being developed, there is a danger in the focus on individuals accessing pools of knowledge verses the socialisation of existing knowledge, leading uncover new insights relevant to the task. A balance between these two elements was seen to be important

These steps are interesting in the light of the research and imply that the team will need to go through iterative cycles of developing the task relevant knowledge which will broadly involve processes of learning before, during and after. The relevance to the framework being developed is that the team must have regular feedback meetings in which to update the other members using a clear feedback process like the AAR session. A focus on accessing pools of existing knowledge was also thought to be useful and this instruction was built into the first pass framework.

What was still unclear at this stage of the research was exactly how the feedback was to be given to the team and how the map was to be updated. It is toward these feedback processes the literature review then focused.

### **2.4.4 Feedback processes**

Most teamwork literature considers feedback to be a core element to obtaining a shared cognition (Frederiksen and White, 1989). It suggests that feedback influences the behaviour of the team by directing the team's attention to a particular aspect of the task; it provides information about performance and provides an opportunity to change behaviour. Vroom (1964) described feedback as having a cue function, a learning function and a motivational function, each in turn having a significant impact on team performance. These three themes have an overlapping function and impact, hence it is not possible to explore each in turn. Various authors such as Kluger and Huff (Kluger, 1993; Huff et al., 2002) have shown that the effectiveness of this feedback can have a negative impact on team performance if the nature or timing of it is not constructive.

The nature of feedback can be categorised into process type feedback, which is feedback on how the task was performed, peer feedback, which is feedback that involves a peer assessment of performance and outcome feedback which

is feedback on the outcome of the process (Earley et al 1990, Lee, Northcraft and Lituchy, 1990). The literature shows that all types of feedback can have positive impact on performance, with the most common type of feedback being outcomes feedback. Kluger (1993) reviewed the literature on feedback and found that most researchers agree that outcome feedback is the least rich of the three types of feedback, with process feedback facilitating the highest levels of shared cognition. The reason given for this is that this type of feedback provides some of the reasons why the technique was effective and how another team member can build on this approach to achieve similar results (Baltzer et al, Sulsky, Hammer and Summer, 1992).

It was found by Norton (1992) that peer feedback has the highest impact on the accuracy of the team and that team members can be an effective source of feedback to help their team-mates develop task relevant understanding and skills. The literature on feedback suggests that generally healthy feedback processes should encompass all three forms of feedback. This finding is however moderated by the nature of the task, with some tasks having a natural bias toward certain types of feedback, given the nature of the task.

### **2.5 Nominal group technique**

The Nominal Group Technique (NGT) first proposed by Delbecq, Van de Ven and Gustafson (1975), uses divergent processes to counter the groupthink tendency. NGT is based on three research-based principles (Delbecq et al., 1975), 'Nominal' groups are thought to generate more and better quality ideas than interacting groups typical of classic 'brainstorming'. A nominal group consists of several people who are prepared to work as a team to resolve a problem. This sharing of ideas (which are anonymously submitted) promotes a sense of involvement and motivation within the group.

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The 'round robin' element provides encouragement and equal opportunities for all members to contribute. Contributions from all participants are encouraged and every individual's idea is given equal standing, whether unique or not.

The NGT process is as follows (Delbecq et al., 1975).

1. Anonymous generation of ideas in writing begins with the facilitator stating the problem and giving the participants up to 10 minutes to jot down any initial ideas privately.
2. 'Round-robin' recording of ideas allows each person in turn to read out one idea, which the facilitator writes up on a flip chart for all to view. This is repeated going around the groups until all ideas are exhausted and any duplicates are eliminated.
3. Serial discussion to clarify ideas and check communication is encouraged by the facilitator, who works through each idea systematically asking for questions or comments with a view to developing a shared understanding of an idea.
4. A preliminary anonymous vote on item importance is usually carried out by submitting a scoring on each of the ideas.

The benefits of the NGT process can be summarised as follows (Dunham, 1998):

- It balances participation across members.
- It balances the influence of individuals.
- It produces more creative ideas than interacting groups.
- It produces a greater number of ideas than do traditional interacting groups.
- It results in greater satisfaction for participants.
- It reduces the tendency to conform, which common to most face-to-face group meetings.
- It encourages participants to confront issues on a problem-solving basis rather than on a personal assault basis.



### **Implications for the research**

NGT does not propose much that has not been taken into account in brainstorming but does address the aspect of ensuring thoughtful contributions from team members through the private generation of ideas. Thus a period of individual idea generation seems to be a useful mechanism to ensure that the concepts presented by each of the members are well thought out and are not simply spurious reactions. The disadvantage of using the nominal group technique is that it does tend to slow down the rate of map development and decrease the time in group behaviour which could have a negative impact on group efficiency. For this reason it was felt that it was important to ensure that the creativity of the team was specifically researched, which is the focus of the next section.

The benefits of this technique were not integrated into the framework until the second case as the action research process highlighted this need.

### **2.6 Teams and creative processes**

There is much debate in academic circles around the issue of groups impacting positively or negatively on the creative process. This debate is however not relevant to this context because as part of the nature of the project there is a team, and one wishes to empower the creativity of the team as much as possible.

Heap (1989) suggests that creativity is "the synthesis of new ideas and concepts by the radical restructuring and re-association of the existing ones". In innovation there is an abundance of literature relating to the early stage in innovation of idea generation, however, from the definition above, it should be clear that creativity is needed along the entire process of innovation, particularly in the demonstration stage where problem solving and problem framing can be facilitated by creative processes.

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Much creativity theory is directly drawn from psychology, and without going into the detail of each approach to creativity, Rickards (1990), summarises the processes that are used in teams to enable creativity.

### **Brainstorming**

This is the most common and oldest of all the approaches to enable the creative process developed by Alec Osborn (1963). It uses divergent processes to create a volume of ideas on the premise that a greater number of ideas will offer a richer view of the issue. Team participants informally generate as many ideas as possible without evaluation by others. This prohibition should reduce the barriers to contributions from members who are particularly shy, have divergent ideas or have low status within the team. During idea generation, team members are encouraged to build on, but not criticise, ideas produced by others. This cross-fertilization is assumed to produce a synergistic effect. The object is to generate as many ideas as possible in the belief that, the greater the number of ideas, the greater the likelihood of at least one outstanding idea emerging.

The following three approaches are common to brainstorming sessions.

- Criticism is prohibited. The judgment of the creative or imaginative solutions to problems should be withheld until all the solutions have been generated.
- Imaginative solutions are welcome. The wider and more 'far out' the solution, the better
- Quantity is important. The greater the number of solutions, the greater the likelihood that there will be an outstanding one.

As the critical discussion stage of brainstorming emerges it also facilitates a level of shared cognition due to the nature of the process.

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The different approaches to creative processes, such as: laddering (Rugg, 1995), lateral thinking (de Bono, 1992), metaplaning, Parnes-Osborn CPS system (Parnes, 1961), and brainwriting can be classified into three broad categories (Kiely, 1993).

**Fluency approaches:** This category of group creative techniques aims to develop flexible habits of mind, suspend judgement and create a volume of possibilities. Brainstorming is the obvious example of this category.

**Excursions:** This category of creative techniques aims to take the group outside the confines of the current thinking to the issue. Lateral thinking is an example of this category. Humour rooms and brain-calming would be techniques that help set the ambience for creativity.

**Shake up exercises:** This category considers the pre-conditions for creativity, the climate, the environment, the group relationships etc.

An analysis of these approaches and categories yields the following elements that should be incorporated into the framework being developed.

- 1) The approach should incorporate divergent fluency processes incorporated, the most common being the brainstorming approach and hence, in order to leverage on that familiarity, components of brainstorming should be incorporated. Research by Kelley and Storey (1998) investigated the preference for a range of idea generation techniques and found that brainstorming came top with suggestion boxes rated lowest. This suggests that incorporation of the brainstorming process into the framework would allow for easy adoption, due to the high level of familiarity.
- 2) The approach of simultaneously capturing ideas on cards to create a volume seems to assist in the efficiency and diversity of the brainstorming process.

Borrowing from both cognitive mapping and ladderling, a categorising and layering of the concepts seems to be important both for creativity and for communication purposes. These techniques were incorporated into the framework.

### **2.7 The team's role development**

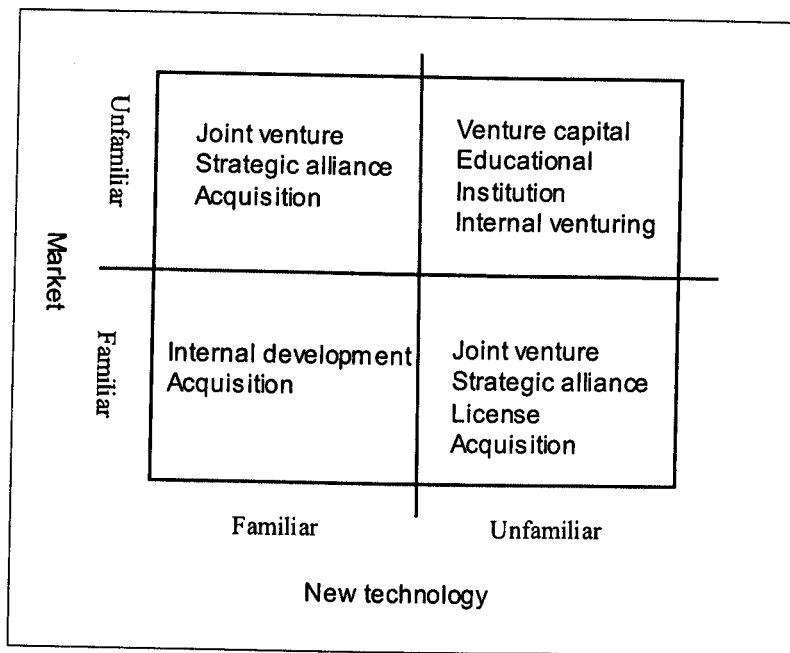
In a cross-functional team there are many roles that an individual (internal or external) can play which can be described in these themes (Sundstrom (1999,pg. 308).

- 1) From a **functional** or technical perspective, the individuals in the group must have the right mix of knowledge.
- 2) There is the **problem solving** and decision-making role.
- 3) **Interpersonal role:** the team must have champions, gate keepers, and sponsors to keep it together.

The role development in a team also depends on the stage of development of the team. In the early stages of a team the internal members do not always fill all the skills needed in the team and a boundary spanning role is needed to bring into the team the technical or functional knowledge from the outside. The literature highlights the importance of linkages to external role players at this stage of the innovation in order to develop the task relevant knowledge rapidly. Afuah (2003) suggests the following Figure 2.4 be used to consider external roles at the different stages of development.

**Fig. 2-4: Internal development or external sourcing?**

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Source: Afuah (2003, pg. 204)

Figure 2.4 looks at the task relevant knowledge from a market and technology perspective and suggests that the mechanism used for developing the task changes depending on how much task relevant knowledge is internal to the team or the company. In most of the projects under research the markets were new but the technology was not new to the technology partner and the business model was a joint venture between the two parties.

The focus of this framework is to develop the role of the team members in developing the task relevant knowledge which is invariably focused in the technical dimension. It is assumed that the other types of roles that the members of the team will play are normalised by standard team staffing practices.

### **2.8 Summary**

The literature review specifically focused on establishing the theoretical underpinning for the framework on enabling the five key themes:

1. the team's development of a shared cognition;
2. the team's creative processes;
3. the team's development of their task relevant knowledge;
4. the team's role development;
5. the team's tracking of the task.

Based on these themes the literature review identified a first pass framework and then through the evaluation of the process by project teams and reflection of the researcher, sections were added that reviewed nominal group technique, creativity techniques, knowledge management and further innovation management and project management literature to overcome the identified weaknesses. This is summarised in Table 2.3 below.

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Table 2.3: A summary of the literature review

Literature review	Literature review support
<b>Team effectiveness</b> In the context of: innovation, entrepreneurship, high rates of change, and high uncertainty	Davenport (1998) De Meyer et al., (2002) Van de Ven et al., (1975)
<b>Dominant themes</b> 1. Shared Cognition 2. Facilitating creative insights 3. Knowledge 4. Roles 5. Tracking	Eden et al., (2002) Rickards (1990) Rugg (1995) Knutson (2001)
<b>Other areas of research</b> Innovation management Knowledge management Project management Creativity processes Cognitive Mapping Nominal group technique	Afuah (2003); Brown et al., (1995) Collison, (2001) Richards (1999) Huff (2002); Nelson et al., (1991) Delbecq et al., (1975)

The framework as developed with a strong grounding from tried and tested techniques would represent an architectural innovation and while the outputs from the framework are context specific it was necessary to establish how generally applicable the framework was. Many themes influencing innovation in teams are outside the scope of the research, and will not be included in the scope of the framework. Because of this, the framework will not be the complete solution for managing innovation in teams but will rather aim to have an impact on the key elements of team effectiveness at the early stages of managing an innovative project.

## **Chapter 3: Research methods**

The study seeks to design, test and evaluate a cognitive mapping framework to aid the process of innovation management in cross-functional teams at the demonstration stage of innovation. A slightly unconventional approach was adopted as described in the architectural innovation description on pg 10. In developing and testing the framework the broad principle followed was an action research methodology.

### **What was being researched?**

The research involved two questions; the first was to design a framework that could elicit a shared understanding of the team's task relevant knowledge at any point in time. The second question involved verifying the ability of the framework to direct the development of the team's task relevant knowledge.

Putting this into different words the framework would be required to develop a shared cognition, facilitate creative insights and knowledge development, as well as manage the process related aspects of task tracking and role management. The research focused on monitoring how effectively these five key factors worked as the framework developed from literature was tested in an innovation team working on an ill-structured problem.

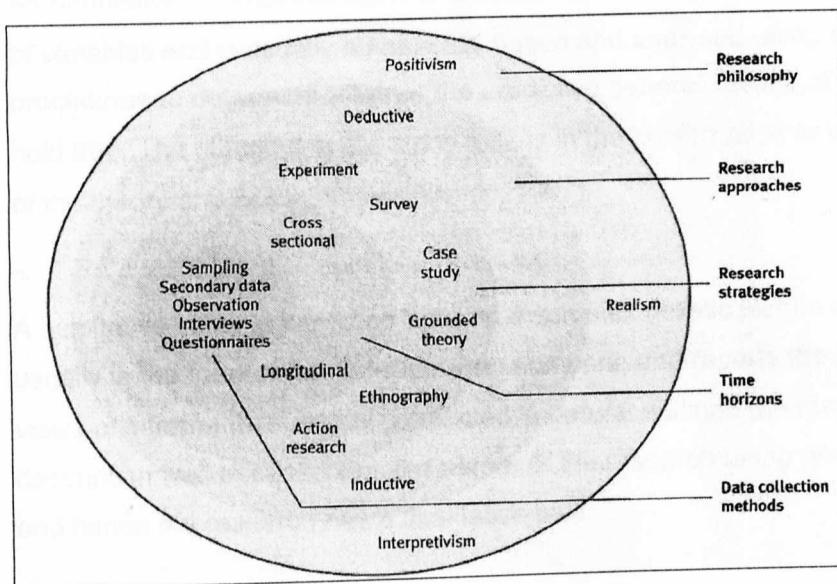
The premise was that the researcher should observe the framework being utilised across a number of teams and projects, and watch for patterns within various sources of data, such as user's assessments, post-mortems after use, and transcripts of the individual's responses to semi-structured interviews. This resulted in the identification of areas in which the framework was lacking, with the literature review and the implementation process being sources of improvement to the actual framework.



### How was it researched?

As the particular research approach was being developed, different conventional research approaches were considered for appropriateness to the research question and context. These research approaches are critiqued in the sections that follow for suitability to the context and questions. The flow of these sections, after section 3.1 follows the structure of the “research onion” described by Saunders, Lewis and Thornhill (2003, pg. 83):

Fig. 3-1: The research process “onion”



Source: Saunders (2003, pg. 83)

### 3.1 Research nature

Exploratory studies are a means of developing a view on what is happening and assessing phenomena in a new light or seeking new insights (Robson, 2002). The earlier informal stages of developing the research problem were exploratory in nature and in fact happened even prior to the thought of undertaking the research in a formalised manner.

Explanatory studies tend to have an element of causality in the approach, with emphasis on studying a problem in order to understand comprehensively and explain the relationships between variables. This research has an element of explanatory studies to it, as the relationship between the use of the cognitive mapping and the development of the team's task relevant knowledge was explored.

### **Qualitative versus quantitative**

A quantitative or empirical study is based on the testing of a theory composed of variables and is usually numerically based and analysed using statistical procedures to determine whether the predictive generalisations of a theory hold true. The outcome of the study results in the confirmation or invalidation of the theory and its hypothesis (Leedy, 1997).

A qualitative study is based on building a complex holistic picture which is usually in the form of words rather than numbers, and reports the detailed views of informants normally conducted in natural settings (Leedy, 1997). This description well encapsulates the nature of the research being undertaken and hence the research has a qualitative bias.

### **3.2 Research philosophy**

The two outlying positions of research philosophy are phenomenological and positivist, with a number of philosophical standpoints that are possible between these two. The research was conducted with an ontological position that tends towards the phenomenological position.

### **3.3 *The research approaches***

#### **3.3.1 Research theory building: induction and deduction**

##### **Inductive processes**

Inductive processes, involve the building of a theory or framework through the study of the relevant theory and the interaction with the subjects in a natural setting. Hence the theory follows and flows from the data.

##### **Deductive processes**

Deductive processes, on the other hand involve a search to explain causal relationships between variables. The stages of progression involve the deduction of a proposition or hypothesis, the expression of the proposition or hypothesis in operational terms, the testing of this proposition or hypothesis and the examination thereof (Leedy, 1997).

The research used a combination of inductive and deductive research methods, with a bias toward the inductive approach at the beginning of the research because the nature of the framework was still being developed and tested on the projects. The research questions and context suggested areas of study, which in turn yielded approaches that could be adopted into a framework, that in turn were incorporated into a first pass framework. This framework was tested on the first project, which yielded learning and weaknesses in the framework, which required a further literature review, and so the cycle continued until it was felt that a robust framework had been developed.

Once the framework was fully developed, deductive type processes were used on multiple cases to infer a generalised theory. This was achieved by observing the impact of the framework on the five themes which influence the development of the team's task relevant knowledge.

### **3.3.2 Research formality and the researcher**

The research approach was informal, with the observer being very much part of what is being observed. This flows from the philosophical stance of the researcher, utilises the researchers prior experience in innovation teams and the uses the fact that the purpose of the research involves the strong social context of teams. To impose more formality upon the study of team effectiveness would run contrary to the nature of the subject under study. The researcher utilised collaborative reflective processes using context, process and premise reflection (Meizirow, 1991).

### **3.4 Research strategies**

#### **3.4.1 Research Strategies: quantitative methods**

The research methods that lend themselves to the quantitative approach are the descriptive research methods which predominantly consist of: surveys and experiments. The experimental or classical approach stems from the natural sciences and is based on the scientific method. It does not easily lend itself to the nature of this specific research due to the difficulty of isolating the variables for the experiment in order to achieve a valid result. Components of the research do however fit with quantitative methods, such as aggregating the responses from the team members (in a Likert scale).

#### **3.4.2 Research strategies: qualitative methods**

Qualitative research methods can take different forms depending on the nature of the research. Examples of unsuitable qualitative research methods are: Ethnography with its primary focus is on studying the natural settings in which culture is manifested and, in so doing, discovering cultural patterns in human behaviour (Leedy, 1997); grounded research as developed by Glaser and Strauss (1967) which while appropriate to the research in some aspects, tends not to focus on prior theory.

The qualitative research approach that best fitted the research context and questions was believed to be action research. Action research itself also adopts different forms. The approach to action research which was adopted and the rationale for the selection of this action research as an approach is described below.

### **Action research**

#### **Definition**

The term action research refers to a particular approach to research methodology, first suggested by Lewin (1963) and further developed by Argyris and Schön (1978).

Action research is so named because of its particular focus on action and promoting change (Marsick and Watkins, 1997). Coghlan and Brannick (2001) note that the purpose of action research and discourse is not just to describe, understand and explain the world but also to change it. In action research the researcher is involved in this action for change and acts as an *'importer of knowledge'*. Eden and Huxham (1996) argue that the findings of action research result from *'involvement with members of an organisation over a matter which is of genuine concern to them'*. Therefore the researcher may be close to or part of the organisation within which the research and change processes are taking place. This suited the approach adopted in this research.

Action research can have two distinct foci (Schein, 1999). The first focus is to fulfil the agenda of those undertaking the research rather than that of the sponsor. This does not, however, preclude the sponsor from also benefiting from the changes brought about by the research process. The second focus starts with the needs of the sponsor and involves those undertaking the research in the sponsor's issues, rather than encouraging the sponsor in their issues. These consultant activities are termed *'process consultation'* by

Schein (1999). The consultant, he argues, assists the client to perceive, understand and act upon the process events that occur within his / her environment in order to improve the situation as the client sees it.

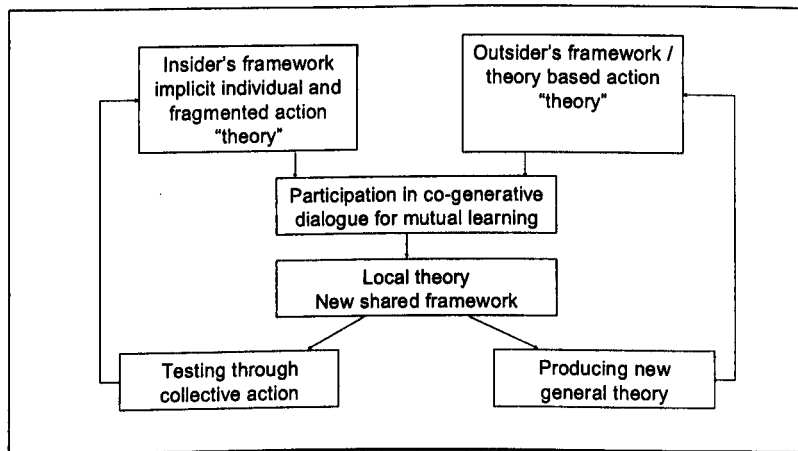
### The nature of action research

Action research can be observed through: its relationship to the participants, the relationship of action to theory, and through a cycle of steps. The steps in an action research cycle have been articulated differently by different authors. The view of action research that was adopted was the co-generative model as described below:

### The co-generative way

Elden and Levin (1991) describe action research through its relationship to the participants' contribution to the process as detailed in the diagram below.

**Fig. 3-2: Action research a co-generative dialogue**



Source: Elden & Levin (1991, pg. 130)

The research would clearly benefit from a co-generative dialogue based on the experiences of all the participants, with each cycle contributing

toward a general theory. This framework highlights the fact that the researcher does not have all the relevant or important knowledge, but through reflective dialogue all participants contribute. This co-generative reflective dialogue was used in this research as many of the participants are experienced in the processes of managing innovation.

Four identified projects were used at the inductive stage of the research and the results are presented in this format. This inductive stage was complemented by a deductive stage to test the final format of the framework against three projects to infer the repeatability of the generalised theory. This was done by observing the same action research steps, but without modifying the framework after each project.

### **Justification for action research**

Action research was chosen as the most suitable approach for the specific research context, as the main themes of action research fit well with the focus of the research as set out below.

- The first was managing change – action research has a focus on the change dimension.
- The process of testing the effectiveness of the process against the experiences of participants and reflecting on the resulting insights enabled a convergence toward a usable framework.
- The collaboration between practitioners and researchers drew on the rich experience base of the participants.
- The research was aimed at developing a generalised theory, which has implications beyond the immediate project (Cunningham, 1995).

The alternatives to action research would have been to adopt a pure case study approach, or to use a grounded theory approach. In the process of developing the research approach, the option to take a grounded theory

approach was seen as the next best option to the multiple-method adopted. The grounded theory approach would have suited the need to develop a framework, but there was clearly significant value in the existing literature, which grounded theory tends to ignore. The researcher believed that the complexity and diversity of influences in the area under study would make grounded research a difficult approach to justify in this context. The generation of predictions that are tested in new contexts is an approach that could have encountered significant criticisms unless very controlled conditions could be established.

The case study approach which was the other possible research strategy is flexible, as defined by Robson and several others (Otley and Berry, 1994; Robson, 2002; Scapens, 1991). It is a research strategy that involves an investigation into a phenomenon within its real life context, using multiple sources of evidence. It is of particular interest when a rich understanding of the context of research is required; when there is an interpretational search for themes and a rich portrayal of participants' views. It is a good way to explore a developing theory in its natural setting and hence is most suitable once the framework has been developed (Leedy, 1997). The different contexts or projects in which the tasks were explored were, however, not full case studies but rather projects where action research was used and in the early stages of the framework development, to undertake full case studies would have been unnecessary. The case study approach differs from the action research approach taken in that the intervention tends to be more of an observation of what exists, rather than adopting the interventionist approach of action research, involving observation of changes taking place whilst implementing a new group process.

### **Validity in action research**

The validity and meaningfulness of the research using an action research method has more to do with the information-richness of the selected cases



and the analytical abilities of the researcher than with sample size (Perry, 2001). Leedy (1997) suggests that a qualitative study should be evaluated according to the eight general criteria: purposefulness, explicitness of assumptions and biases rigour (rigour in action research refers to how data are: *'generated, gathered, explored and evaluated, how events are questioned and interpreted through the multiple action research cycles'*). (Coghlan et al., 2001, pg. 23), completeness, coherence, persuasiveness, consensus and usefulness.

The researcher regularly revisited these criteria during all stages of the action research cycle and made every effort to ensure that the process retained validity and objectivity, but followed the set of criterion described by Reason and Bradbury (2001), which is specifically applicable to action research, asking is it:

- Explicit in developing a praxis of relational participation?
- Guided by reflexive concern for practical outcomes?
- Inclusive of a plurality of knowing?
- Worthy of the term significant?
- Emerging towards a new and enduring infrastructure?

These are used to aid reflection on and evaluation of, the research in Chapter seven.

### **3.5 Research time horizons**

As the research topic involved an investigation of the development of task relevant knowledge over the duration of uncertainty in the task, time plays an important role. For each action research cycle, a longitudinal mapping process was undertaken for each project up to the point where the framework had fulfilled its core function. The group collectively evaluated the process after each mapping session and individual interviews were held with group members in the intervening periods between mappings.

### **3.6 Map building, data collection and analysis**

The action research method of pooling the experience of all the stakeholders, the insights from literature reviews, and the reactions to the use of the framework to drive forward the refinement of the framework is only effective if this process of pooling adequately captures the data from these idiographic sources and fairly interprets it. This section describes the data collection and interpretation process that were used.

#### **Data Collection**

Data collection in qualitative research is best done through a variety of data sources. Mason (2002) suggests that data may be garnered from:

- people,
- organisations, institutions and entities,
- published and unpublished texts,
- settings and environments,
- objects, artefacts, media products, and
- events and happenings.

Data in the action research process followed would best come from observing the event in which the framework was used. Insight comes from the collaborative evaluation of this data, working with people in a number of real business settings, thus utilising three of Mason's six sources, namely people, events and published texts. Outside the literature review there was two explicit sources of data, the processes of observing the group sessions that generated and updated the cognitive maps, and the one-on-one semi structured interviews with the team members. The data collection and interpretation mechanisms involved in each of these sources were as detailed below.

### Group sessions

Idiographic concepts were elicited using the nominal group technique, and all concepts were presented on a board on oval slips with verbal explanations offered and captured on the back of the oval slip. This allowed the group to develop a shared sense of the meaning and boundaries of each concept. Group consensus was used to eliminate duplicate concepts or concepts with syntactical equivalence.

If consensus was not achieved the concept was retained, and very often it was possible to achieve consensus on the relevance of the concept once new knowledge had surfaced. The same group consensus process was used to form categories of concepts, to represent this cluster by an equivalent potent construct and then hierarchically order the sub-concepts into a ladder. Details of the facilitation processes used for this are described in the appendix and results chapter of this document.

The voice data from the actual group sessions was captured on an audio recording of all mapping sessions. This recording was not transcribed fully into written format because of the volume of data that was involved. There were nineteen mapping sessions involved in the four projects during the inductive rounds and fifteen mapping sessions in the three deductive round projects. Each mapping session can take from 20 minutes to 3 hours, and hence a great volume of data was generated, much of which was technical in nature and focusing on the project. There were however useful insights resulting from both facilitating the sessions and from reviewing this data. The researcher used a post-mortem process of review of each mapping session which occurred the day after each mapping. This reflective review involved listening to the audio transcripts and simultaneously making notes of patterns, observations and detail of context were the framework appeared to not be effectively facilitating the team process. Notes and reflections were made as to why this was believed to be the case. The team leader for each of the projects also reviewed these notes and added any comments or thoughts.

### **Semi-structured interviews**

Semi-structured interviews with the team and with individuals in the intervening period were best suited to the research methods chosen as the collaborative evaluation of the framework needed to be carried out in a reflective manner that sought connections to the participants' thoughts and feelings to allow tacit learning to become apparent. This would be difficult to do with highly quantitative, structured instruments.

Mason (2002) believes that a semi-structured interview is most typical of qualitative research and that the exact degree of structure or lack thereof is determined by the cases and the research problem. Too much structure has the disadvantage of stripping out the context and overlooking important underlying constructs. Too little structure may lead to too much superfluous information or selective, unreliable observations. A further problem arising from too little structure is the difficulty in communicating across studies without a common instrument (Miles and Huberman, 1994). The semi-structured interviews involved a discussion with each of the team members to extract their observations of the process.

There were nineteen mapping sessions involved in the four inductive projects with a varying number of team members in each project which resulted in exactly 100 semi-structured interviews during the inductive rounds and 50 semi-structured interviews in the three deductive round projects. Each interview used a semi-structured questionnaire as a guide to the discussions to allow for both context-specific and cross-case analysis. The semi-structured template is set out below with a completed sample given in Appendix A.2.

The entire sheet was completed by the researcher and the results were reviewed by the respondent and the end of the interview to verify that the data captured correctly expressed the views of the respondent.

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The numbers at the top of the semi-structured questionnaire refer to the team member that was responding questions in the format of a Likert scale, which is detailed in the table key below that table. The respondents were asked to evaluate each of the five key dimensions on the Likert scale and additional comments on the frameworks strengths and weaknesses as well as observations on the process were elicited and recorded. Not all respondents offered additional data.

Managing innovation through cognitive mapping

PROJECT DESCRIPTION:

DATE:

INTERVIEWEE:

Map update number:

Variable / Team member	1	2	3	4	5	6	7	8
<b>1) Communication: (shared cognition)</b>								
Evidence of a common vocabulary.								
Evidence of concept retention.								
Use of map for external communication.								
<b>2) Creativity:</b>								
Evidence of divergent insights.								
<b>3) Task relevant knowledge (TRK):</b>								
Does the map represent everything you know?								
Do you know what you don't know?								
Accuracy in developing task relevant knowledge.								
<b>4) Team roles:</b>								
Do you know who is doing what?								
Evidence of duplication of work.								
<b>5) Tracking:</b>								
Evidence of the use of other tools.								
Time spent on tracking.								

<b>Table Key:</b>	++ very effective	+ effective	0 neutral	- ineffective	-- very ineffective
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Other information of relevance:


### **Data Interpretation (inductive rounds)**

The process of interpreting the data involved the following longitudinal intervention in each of the inductive projects.

#### **1. Group briefing, project definition and mapping took place.**

Develop cognitive map (**Action**) and **evaluation**. This evaluation step was done after each mapping as semi-structured interviews with different members of the group. The data from the mapping and all the semi-structured interviews were analysed to establish patterns in the data, which highlight areas of strength or weakness in the framework. The patterns were tracked in the written transcripts through colour coded highlighting of phrases or comments that referred to that suggested weakness. This inference process would only translate into a stated weakness once a self evident pattern asserted itself across multiple respondents, and multiple sources of data.

#### **2. Based on the evaluation of the previous step, the framework was reviewed to see what changes were needed and a plan was developed for the next mapping.**

This evaluation process was facilitated by noting relatedness, observing common meanings attributed to events and actions, and considering the time dimensions of how delays had an impact on concept retention and the task relevant knowledge. Opportunities were created for participants to offer alternative explanations and, if contradictory views were held by participants, these views were explored to establish the basis. There was a bias on the part of the researcher not to challenge the general theory until a strong pattern supported by all the collaborative members had emerged. Notwithstanding it is recognised that personal judgements had to be made in this process.

3. Steps 2. and 3. above were repeated until the main uncertainties had been eliminated from the project and the group felt the framework had fulfilled its function.

**4. Summarising the results into a single view in the time ordered explanatory effects matrix.**

The participants' view of the effects of the use of the framework on the variables over the period of use was captured by means of a five point Likert scale.

(++) strong positive impact i.e. very effective;

(+) represents some positive i.e. effective;

(0) represents no noticeable impact on the variable;

(-) represents some negative impact i.e. ineffective;

(-- ) represents a strong negative impact i.e. very ineffective;

This data was summarised into a time ordered explanatory effects matrix that captures the feedback on the Likert scale at each iteration of use (Miles et al., 1994), for each project, as detailed in Table 3.2 below. It is recognised that a strong positive impact for one respondent is not equivalent between respondents, and so normalisation effects are bound to occur.

The purpose of this matrix is to visually represent the impact of the framework on the five key variables over time, to try and establish when the point of highest utility is reached for each project and each variable, and what contributed to the co-incidence of that point of highest utility. While it is outside the research question, it would be important to users to be clear on what to stop using the framework. The visual representation also establishes how well the five key themes were progressed by the use of the framework.



Table 3.2: Time ordered explanatory effects matrix:

Project number		1		2		3		4		5
Variable / Time period number		1	2	3	4	1	2	3	4	5
1) Communication: Evidence of a common vocabulary Evidence of misunderstandings. Use of map for external communication	++ + 0 --									
2) Creativity: Evidence of associative thoughts being included & periods of divergent processes	++ + 0 --									
3) Task relevant knowledge: Does the map represent everything you know? Do you know what you don't know? Accuracy in developing task relevant knowledge	++ + 0 --									
4) Team roles: Do you know who is doing what? Evidence of duplication of work	++ + 0 --									
5) Tracking: Evidence of the use of other tools. Time spent on tracking	++ + 0 --									

Source: adapted from Miles & Huberman (1994, pg. 140)

### **Data Interpretation (deductive rounds)**

Once the inductive rounds were completed, the research strategy suggested a deductive process that used the **same framework**, unchanged over three projects with the same interpretative processes to explore if any further areas of improvement surfaced for the framework. The objective was to establish a pattern of good utility of the framework as evidenced through the time ordered explanatory effects matrix, which supports the assertion that the framework contributes to a general body of theory.

### ***3.7 The initial framework developed***

The initial format of the framework that was followed, as developed from the literature review, is set out below.

#### **Step1: Define the operating concepts**

Operating concepts can be defined as the central concepts that will guide the development path, and effectively encapsulate the task description. (oval mapping technique (Eden et al., 2002))

The broad operating concepts involved in the product development must be established using the typical stages involved in the value chain as a guide (e.g., research, test, pilot, commercialise, market as described by (McAdam et al., 2002) ). The task objective was placed in the centre of the paper and linked to the operating concepts clustered around it. No more than five operating concepts (as described by the product development value chain) were defined as otherwise the operating concepts tend to become too detailed.

**Process details:** As the main interest of the cognitive map is to expose a system of relations, relating to a particular focus, it is important to be clear up front what the project is about and be able to concisely state

this in the centre of the page. The outcomes, project boundaries and any literature and information relating to the project was disseminated prior to the first group meeting in order to allow the team to at least orientate themselves on the project. The selection of pre-structured constructs as described in the step above was found later in the research to limit the usefulness of the framework and was altered as detailed in the final format of the framework in the results section.

The team worked on a large board with the cognitive map being manually developed and captured in software afterward for dissemination amongst the team members, and the session was recorded on audio equipment for review afterward. The facilitator would introduce the project briefly, describe the operating concepts to the team members, and check their relevance to the project.

### **Step 2: Mapping from broad concepts down to events**

A visual relational mapping is evolved as described below.

- 1) Each operating concept has an uncertainty of actualising because one is dealing with future events in an uncertain environment (Corti et al., 2000). Write down the middle tier concepts or events that constitute the uncertainty around the relevant operating concept. Arrows must be added from the originating concept to the concept a level below.
- 2) The process is repeated until all the middle tier concepts have been mapped (laddering as described by Rugg (1995).
- 3) Where new middle tier concepts relate to already mapped events or concepts, arrows are also added. (Eden, 1992)
- 4) This process is then repeated at the next level until the team is unable to drill down any further. (Collison (2001))
- 5) The concepts represented at the bottom of the maps are allocated to team members to explore as actions to eliminate the uncertainty

and build the task relevant knowledge surrounding that concept.  
(Collison (2001))

**Process details:** Using the word uncertainty as a driver the facilitator would call on the discursive mechanisms of natural logic to try and extricate the cognitive organisation of the schema that expresses the hierarchical representation of the uncertainty involved in the project. This did require the researcher to interact with the team, and thereby affected the representation. Again there were limitations uncovered in the process and it was altered to the final format described in the results section but the specific mapping process details described above involved individuals offering the uncertainties they perceived on the "Ovals" and amassing all the concepts reflecting the uncertainties associated with the project around the task. The redundancies were eliminated on the basis of consensus, and a hierarchy was established by placing the sub-ordinate concepts below the parent with arrows emanating from the parent linking the two. This process was then repeated at the next level until the team was unable to drill down any further, with the concepts at the bottom of the ladder allocated to the most relevant team member/s to explore and reduce to a certainty.

### Step 3: Updating the maps

As the team members develop a better understanding of the concept, the uncertainty and task relevant knowledge associated with it, they are be required to remap this understanding into the teams map. This is done in the group as a means of sharing the experiences of the group and developing a shared cognition. (Collison (2001) and Eden et al., 2002). This was done using the same methods of eliciting the original map, and often use was made of sub-maps developed by individual team members in the interim. The closing instruction was always to explore existing pools of knowledge to unpack and rapidly develop the knowledge needed to deal with the uncertainty

**Process details:** The team used the original map as a basis for starting the feedback which took the form of each team member giving a verbal updating of the progress on the uncertainty allocated to them, with care taken to update the map on the further uncertainties that had evolved in the interim.

Both process and outcomes related feedback was elicited with particular emphasis on areas that overlapped with other team members. Once the feedback was completed and the map updated the same process was followed as described in step 2 of exploring other uncertainties that might exist that have now come to light give the higher levels of task relevant knowledge the team possessed at that stage.

### **Conclusion**

This chapter attempted to highlight the action research method that was followed while building a justification for the selection of this method. The chapter described the specific data collection methods and processes. This chapter then provides a context for the more specific detailing of the project context which is the focus of the next chapter.

## **Chapter 4: The context of the projects**

The researcher seeks to develop a framework that enables the development and direction of task relevant knowledge in the context of cross-functional teams that are undertaking tasks in complex environments where prior task relevant knowledge is low. As the framework only has utility in the context described, section 4.1 details this context clearly, with section 4.2 (inductive) and 4.3 (deductive), focusing on the specific context of the projects.

### **4.1 Team context**

A review of the definitions of teams in the literature yields the following common elements:

- a team is a small number of people,
- with complementary skills,
- who are committed to a common purpose,
- who have a performance goal,
- an approach to the task for which they themselves are mutually accountable.

The various elements of this definition will be used to describe and review the context of the research and the relevant literature.

#### **4.1.1 Team context: A small number of people**

The process of creating a team can profoundly affect its ability to perform. This can be as a consequence of the composition of the team, the size of the team, the suitability of the team to the task, or the boundaries of the task. In all cases a standard team formation process to develop a charter was followed.

### **4.1.2 Team context: complementary skills, roles & purpose**

More recent models of innovation management have come to see the innovation function as: inter-company, market orientated and cross-functional (Calabrese, 1999; Afuah, 2003). Teamwork has become a core ingredient to effecting increasingly complex development tasks. The roles in the team were chosen on the basis of the functional skills brought to the team rather than the team roles described by Belbin (2000). In all teams there was a clear team leader and a project manager and in some cases the two roles were combined and carried out by one person.

The cross-functional teams were composed of individuals with a similar level of qualifications and the teams involved were of similar sizes. The teams all had low task relevant knowledge at the outset.

Team effort may be crucial at the start-up-stage, when firms need a variety of resources in abundance, but lack most of these.

### **4.1.3 Team context: commitment to a common purpose.**

The history of the project for continuity into the Skunkworks phase was supplied by one founding team member who had been involved in the earlier phases of the project development. The management team developed a team charter in the pre-formation stage which identified, amongst other elements, the task purpose, with clear boundaries, a definition of success for the team, measurements for the team, and a clear communication of expectations (Sundstrom, 1999).

This team charter was understood and agreed on by all the team members in all the cases under research.

Calabrese (1999) and Berczak (2001) show that the setting of clear objectives and a clear performance goal significantly affects team efficiency and hence the outcome of the product development process.

### **4.1.4 Team context: mutually accountable**

Each member on the team had a significant personal interest in the success of the project, apart from the motivation of possible performance rewards, the possibility of the members of the team being involved in the growth phase of the project was good, if the project succeeded. Each team member was considered for selection once they had shown the initiative to propose himself or herself as candidates to the team. It was hence assumed that the teams consistently had members who were motivated to succeed in their roles.

While the interpersonal effects of teamwork are not the focus of this study, it is clear that any approach must be a combination of both the individual and the group to extract the best of both worlds (Richards, 1999).

Given this context of the research, the literature was reviewed to determine the themes that influence the effectiveness of a team and which of these themes have a particular impact.

### **4.1.5 Research context – models of innovation**

In all the projects under research, the markets were new but the technology was not new to the technology partner and the business model was a joint venture between the two parties.



### **4.1.6 Company context**

The institutions selected for the inductive projects were all small to medium sized companies in similar industries. The companies were all at the early stage of exploring an innovative opportunity which formed the basis of the tasks for the various teams. The tasks had medium to high levels of complexity. In the deductive round, this restriction was amended slightly to determine the range of applicability of the framework

### **4.2. *The specific project context: (inductive round)***

The Sections 4.2.1 to 4.2.4 describe the company background, the approach to a solution and the team characteristics in the inductive round of four projects. Section 4.2.5 summarise the key features of each of these projects. Sections 4.3.1 to 4.3.2 summarises the three deductive projects and Table 4.3.3 depicts the key features of each of these projects.

### **Pre-pilot projects: working on innovation projects**

The research problem was well developed but no strong prior theory dealing with model building emerged from the experiences of the researcher. These experiences made it clear that many dimensions can have varying impacts on team effectiveness to varying levels in different contexts. In the context of a cross-functional entrepreneurial team working on a venture new to the team, it was important to establish which dimensions were of importance, and as a consequence where to focus the initial review of the literature.

MBA students were asked to start new, innovative business ventures as part of their entrepreneurial module. Their group work was monitored for patterns

and features in evidence in groups that seemed to achieve a shared cognition quickly.

It was clear from the pre-pilot work of four such MBA teams that participants struggled to reach agreement on what the task was and how to take it forward. It was also noted that some of the participants were consistently focused on the details while other participants were always trying to diverge with creative ideas and others were only comfortable with working with the big picture. There was clearly the need for an approach to guide the development of a shared vocabulary amongst the team.

The outputs from these four MBA projects and the experiences of the researcher consulting on innovation teams, it was clear that the following needs of a group in the described setting are:

- a) a shared world view
- b) a shared vocabulary
- c) a means of linking the central idea to the detail.

A subsequent literature review of the areas of teams, innovation management, uncertainty, change and project management, quickly identified cognitive mapping, knowledge management, nominal group technique and brainstorming, as building blocks that could contribute to the development of the framework. This process resulted in the first framework dealing with how team effectiveness could be enhanced in the context described. This framework was used in the inductive projects.

### **4.2.1 The context of project 1: TEFLON**

### **Introduction**

TEFLON is a specialist plastics converter. The main processes in the company involve the pressing of the raw material by hydraulic presses to create cylinders of the compressed material. These cylinders, called billets, are sintered in industrial ovens which result in the final product.

### **Background to the problem**

The company had a very clear problem of extremely high scrap rates as the plastic is very sensitive to the processing conditions.

### **The approach to a solution**

The team first had to decide on what the best permanent solution to the high levels of product rejections in the company. Using typical brainstorming techniques, they arrived at the conclusion that, while there needed to be several process interventions to reduce the levels of scrap, the ability to reprocess the scrapped material was a core ability. The rationale was based on a benchmarking exercise which determined that the high levels of scrap were fairly common among Teflon converters due to the sensitivity of the material.

The benchmarking exercise also determined that no commercial Teflon reprocessing was yet done in South Africa but had been achieved with varying levels of success from a quality perspective in a handful of companies around the world. Hence the technical feasibility of reprocessing Teflon was confirmed but the team had no idea of how to go about this process.

### **Team composition**

A task team was constituted to explore the problem, develop solutions and implement the best option. The team was cross-functional and consisted

originally of five, and later six, members with the following roles: the project manager who was the works manager and was very knowledgeable on the processes, a marketing person who was clear on the market requirements, a shop floor fitter / turner who was familiar with the practical details, the technical research and development person, the quality assurance manager, and an outside specialist in reprocessing techniques (he was the later addition to the team). The team used the framework to manage the project from conception and the researcher facilitated four iterations of the team and conducted 28 semi-structured interviews during this process.

### **4.2.2 The context of project 2: FLAVOURS**

#### **Introduction**

The South African flavour and fragrance industry is small, and dominated by traditional non-organic flavours. The industries are growing at 3% per annum with an increasing awareness surrounding healthier lifestyles, which will enhance the demand for organic flavourings. These organic flavourings can be cost effectively grown through a fermentation process by a technical research body. The process that has been developed by the research body cannot be easily duplicated as the raw materials used are only found at certain very specific locations and the development process has been patented. The process has only been proven on two flavours and the feasibility of producing other flavours and fragrances in a similar fashion is currently untested and hence a risk. Any additional flavours would take two years to develop. This limits the initial earning potential in the short term, but does provide a basis for growth.

#### **Background to the problem**

The problem is that the research body has the technology but no market knowledge or distribution channels or business competency to exploit this

technology. The research body is thus unsure of which two further flavours should be produced that would be in the greatest demand.

### **The approach to a solution**

The research body estimated that the full-scale production of the two tested flavours could be started within one year. As some seasonality exists, the research body suggests that (at least) four flavours should be produced to meet the demands of the market.

The research body has engaged with the entrepreneurial team on a joint venture basis to play a role in the commercialisation process and to provide input into what further flavours to develop.

### **Team characteristics**

A commercialisation team was formed consisting of four people, two from the technology provider and two business people. These individuals would comprise the management team responsible for all aspects of the commercialisation of this product.

The technology development was managed by two individuals that have considerable project management, process development and technology commercialisation expertise. The one engineer was responsible for the pilot plant and was in charge of all the production elements and the other was a chemist with the theoretical and analytical experience.

The commercialisation component was managed by two entrepreneurs with good business experience, and MBA qualifications, but no specific exposure to this industry.

In all 32 semi-structured interviews were conducted on this project, with the researcher facilitating six iterations of the use of the tool.

### 4.2.3 The context of project 3: FISH

#### Introduction

Koi keepers all around the world are familiar with the symptoms and outcomes of what is commonly known as “springtime” disease, which causes ulcers on the skin of Koi. Any small lesions on the Koi are infected by pathogenic species of bacteria.

The bacteria can and often do cause the death of these expensive fish. Ulcer disease is predominantly caused by the bacterial strains of *Aeromonas* and to a lesser extent *Pseudomonas*. The principle of competitive exclusion is well known in nature: This is when one or a group of organisms have the ability to out-compete a pathogen. The success of the competitive inhibitor is related to its advantages in growth rate in a particular environment. These inhibitors are highly fastidious organisms that instantaneously mop up residual waste, thereby starving other pathogenic organisms of essential nutrients.

A team of microbiologists have sourced a series of naturally occurring non-pathogenic organisms, these non harmful organisms out-compete *Aeromonas* and *Pseudomonas*. Application of these bacteria to a Koi pond has resulted in an 80% decline in pathogen count in just two weeks. This resulted in a successful proof of concept of the technology. Field trials thereafter extended to eight ponds in South Africa with good preliminary results.

### **Background to the problem**

The annual loss to the aquaculture market is estimated at 40% due to disease, water quality and nutrition. Use of antibiotics and chemicals are the conventional methods of disease control but these are losing their usefulness due to revised safety regulations, environmental concerns and loss of efficiency because of the development of resistance to the antibiotics.

The biological products currently offer the best available solution to these problems. The products aim to replace conventional chemicals with a beneficial cost-ratio to the end user. The market is relatively new and there is significant advantage for substantial market share. The problem is that the pilot development needs to be expanded into a full commercial venture.

### **The approach to a solution**

An investment of R 6 Million has been made to develop and finalise these technologies for commercial exploitation. This investment has come from three businessmen who have some exposure to the Koi market. This new start-up team has to manage the commercialisation of this technology rapidly.

A conservative market share of 4% has been targeted for the inception stage, which should result in an internal rate of return (IRR) of 55%. A further growth of 20% is envisioned as the new products are developed. The risk of the venture has been reduced by planned product roll-outs, minimal capital investment and a strategy to remain in tune with consumer requirements throughout the technology development and commercialisation phases.

The product is split into two separate products targeted at two separate aquaculture market segments:

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AB - targets high value, niche markets such as the ornamental carp and tropical fish markets;

AC - targets the mass aquaculture market for edible species.

The project was engaged at the stage of development listed below.

Technical: the AC is an early stage product, and the concept has been proven in-vitro at laboratory scale. It comes in a dry powder form. The technology risk is substantially reduced because it is based on the already established successful technology platform of AB.

Commercial: a completely new set of commercialisation people were recruited with no experience in this technology and some marketing experience in the aquaculture industry.

### **Team characteristics**

A commercialisation team was formed consisting of five people, two from the technology provider and three business people. These individuals would comprise the management team responsible for all aspects of the commercialisation of this product.

Project responsibilities became divided between the two management teams to reflect the separate, but equal priorities, required for the innovation process i.e. technological capabilities and commercial viability.

Technology Development was managed by two individuals who have considerable process development and technology commercialisation expertise. The technology commercialisation expertise provides a strategic link to the commercial development team and their endeavours to take the



product to market successfully. The one person was more practical and involved in the pilot, while the second person retained the theoretical understanding of the product.

The commercialisation team consisted of a project manager (who later become the managing director of the spin-off that resulted), the production person and the marketing and sales person who had some experience of the aquaculture market. The framework was as a task management tool and the researcher facilitated five iterations of the tool. Altogether 22 semi-structured interviews were conducted on this project.

### **4.2.4 The context of project 4: SKIN LIGHTENER**

#### **Introduction**

The objective of the project was to achieve success in commercialising a local innovation that involves the extraction of a natural organic ingredient which has great pharmacological use as a skin lightener. AF is found in abundance in the Southern and Western Cape areas of South Africa as a naturally occurring plant.

AF is used as an active ingredient in the manufacture of skin lighteners at the pharmacological level. The product acts on the Tyrosinase enzyme, which is responsible for the production of Melanocytes, which are the cells that give the dark skinned people their brown skin colour. AL inhibits the creation of the Melanocytes by negatively affecting the co-enzyme Tyrosinase and hence all its uses rely on this property.

The major demand for this product is in the Far East. The Far East is the most populous region on this planet and a major part of this population is not light skinned. The high demand for skin lighteners is driven by the need in the Far East for a lighter skinned look. The drivers for the skin lightening products are

mainly cultural in some parts of the Far East. In India, the class system accords individuals with lighter skins a certain level of class (normally a higher class compared to their darker compatriots).

The plant for manufacturing the product as well as the intellectual property resides with a research institute. The research institute has the capability to manufacture 8300kg of the product per annum.

### **Background to the problem**

The problem is that the research body has the technology but only possesses poor market knowledge, with weak distribution channels and a low business competency to exploit this technology.

### **The approach to a solution**

The research body has engaged with the entrepreneurial teams on a joint venture basis to play a role in the commercialisation process and to provide input into what other products to develop.

### **Team characteristics**

The team consisted of seven members. The technical aspects of the pilot production of the product were represented in the team by a research and development person from the research body. The balance of the members were from the following functional areas: two in sales, two in production, one from finance, and a project management / administration person. The framework was as a task management tool and the researcher facilitated five iterations of the tool. Altogether 28 semi-structured interviews were conducted on this project.

### 4.2.5 A summary of the inductive projects

The salient features of the first four projects is summarised in the table below.

Table 4.1: Inductive projects summary

Project number	Number in Team	Composition of team	Number of interviews
Project 1: TEFLON	6	Research & Development, operations, sales, quality assurance, project management, and a consultant	28
Project 2: FLAVOUR	4	Research & Development, technical commercialisation, operations, marketing & sales	32
Project 3: FISH	5	Research & Development, technical commercialisation, operations, marketing & sales, and project management	22
Project 4: SKIN	7	Research & Development, two in sales, two in production, one from finance, and a project management person	28

## 4.3 The specific project context: deductive round

### 4.3.1: Project 5: SOFTWARE

#### Introduction

The company specialises in the implementation and support of SAP Human Resources (HR) systems and is striving towards being a *Centre of Excellence* for SAP R/3 Human Resources business solutions in both the private and public sector.

The company has skills in all areas of the implementation, customisation and support of all the different sub-modules of SAP R/3 HR.

### **Background to the problem**

The SAP HR implementation field is under increasing pressure to achieve quicker more cost effective implementations, and in response to this need the company has conceived the development of a pre-configured quick build solution. This provides their implementers with pre-built standard modules that can be used as components in their customised implementations.

### **The approach to a solution**

This approach requires that the documents, templates and subroutines that each of the implementers have developed over the years be understood by the entire group of implementers, and a best practice architecture must be developed out of this shared understanding.

### **Team characteristics**

The company has made available to the project eight of their top implementers to develop the architecture over a three-month period. The team met once a week for three hours to update the groups understanding and the process was facilitated over the entire period by the researcher, with nine iterations of the framework, resulting in 19 semi-structured interviews. The team had one project manager and one marketing person, with the balance of the members being specialists from the different SAP modules.

### **4.3.2 Project 6: CAROTENE**

#### **Introduction**

CAROTENE is a start-up company, formed with the purpose of producing a basket of natural carotenoids for the international market. This process will involve an aggressive expansion plan, with natural  $\beta$ -Carotene as the initial product offering, later supplemented by additional carotenoids such as

astaxanthin and lutein. CAROTENE will derive these products from various strains of naturally occurring micro-algae via similar technology similar to that implemented for the production of  $\beta$ -Carotene.

$\beta$ -Carotene finds application in the food, nutraceutical and cosmetic industries and is produced either synthetically or naturally. Natural  $\beta$ -Carotene, such as CAROTENE's, is produced specifically for a parallel niche market, which is not accessible to the commodity synthetic version.

The food industry exploits  $\beta$ -Carotene's colouring properties. This is a mature market that is dominated by synthetic producers, and constitutes approximately 60% of all  $\beta$ -Carotene consumed. There is a small but growing market, inaccessible to synthetic producers where health food producers use natural  $\beta$ -Carotene in order to label their products as 'all natural'.

Modern diets lack the essential vitamins and trace elements which are required to address the stress associated with modern day lifestyles. As a result there is an ever increasing awareness of, and demand for, supplemental nutrition or nutraceuticals. Natural  $\beta$ -Carotene is an ideal natural anti-oxidant, as well as being a source of bio-available Pro-Vitamin A, both of which have been proven beneficial and in some instances critical to ongoing health. This has fuelled  $\beta$ -Carotene's increasing market share in this rapidly growing segment.

Through its natural anti-oxidant properties,  $\beta$ -Carotene retards the ageing process, thus finding wide acceptance in the multi-billion dollar cosmetic industry and its quest to halt the aging process.  $\beta$ -Carotene has the added advantage of providing a natural healthy appearance to skin.

Due to the small quantity of  $\beta$ -Carotene required in the local market, these products will be produced exclusively for the international pharmaceutical, complementary medicine and OTC markets. As a result, these products will have to be produced in accordance with the strictest international quality requirements. A conservative price structure would be: €730/kg (as pure  $\beta$ -Carotene) for oil formulations and €1600/kg (as pure  $\beta$ -Carotene) for powder formulations. Current market indications are that these prices could be between 15 and 30% higher, depending on the type of supply contract. For simplicity CAROTENE has assumed that all products will be sold at the lowest price and through the most complex supply chain.

$\beta$ -Carotene and other carotenoids are high value added products typically produced on facilities with a high initial investment cost and relatively low operating costs. CAROTENE has secured a license agreement with MB (a technology partner) for a novel process that reduces the CAPEX barrier to entry. The process allows for higher production rates of algae per square metre and hence a substantial reduction in CAPEX, affording CAROTENE a significant competitive advantage. In spite of the novelty of the technology, it has been proven and refined by the technology partner on an operating pilot plant in Uppington over the past four years.

### **Background to the problem**

While the technology has been well developed at the pilot plant, the expansion of the process into a full production facility involves a number of complications and uncertainties that need to be managed by the project team.

### **The approach to a solution**

CAROTENE will enter the market with a 30% oil and a 1% powder formulation. These products are intended to be a one-to-one replacement for Cognis products. Cognis is currently recognised as the leader in the natural  $\beta$ -

Carotene market, so emulating their products presents a good market entry position. However, over time, CAROTENE intends to become a contender for this position, by developing new formulations.

CAROTENE intends to commission its production facility adjacent to the facility in Upington, as it has been found that this area provides some of the best growing conditions for the algae in the world. In addition to this location advantage, CAROTENE will also have the opportunity to contribute to a traditionally impoverished community.

The capacity of the plant will be phased over a period of five years, from an initial volume of 1.375 tons per annum to a final volume of 5.5 tons per annum of pure  $\beta$ -Carotene.

### **Team characteristics**

CAROTENE was a team of young South African entrepreneurs who are all professionally qualified, and driven to see CAROTENE succeed. The team consisted of four members. The technical aspects of the pilot production of the product were represented in the team by a research and development person from the research body (PhD in Chemical Engineering at WITS University with two years experience in the pilot plant). The balance of the members were from the following functional areas: one from sales and marketing, one in production (a chemical engineer with operations support experience, as well as product development and client experience), and a project management / general management person (a graduate electrical engineer with a broad base of experience in executing projects locally and internationally). The framework was used as a task management tool and the researcher facilitated three iterations of the tool. Altogether 18 semi-structured interviews were conducted on this project after which it was abandoned due to the lack of finance for the expansion of the pilot plant within the seasonal window. The

entrepreneurs will resume their consulting work and again try to raise finance next year at the same time.

### **4.3.3: Project 7: EMPOWERMENT**

#### **Introduction**

South Africans often proudly refer to the country's miracle of the peaceful transformation to a democracy in 1994. This, however, was the start of an even longer and more arduous journey: that of the economic transformation of the economy and economic re-distribution through black economic empowerment.

This economic transformation is a business necessity, but how to transform so that ones business is in the strongest position possible thereafter is a fundamental question with which the company assists their clients.

This start-up business aims to deliver three specific value offerings:

- **Strategy development:** this is a clear documented transformation strategy with implementation plan, developed through facilitated workshops.
- **Empowerment Rating:** this is a BEE balanced scorecard development with independent verification.
- **Supplier assessment:** this is a report detailing the BEE status of your suppliers in line with ones preferential procurement policy.

#### **Background to the problem**

In order to report a company's empowerment balanced scorecard, it is necessary to be able to verify the scorecard independently. This independent verification is difficult in the ownership dimension as, if there is corporate



ownership, then one needs to verify the empowerment in that corporate. In South Africa due to economic isolation in the past there is a complex web of cross investments that makes this a circular referencing. This confusion contributes to fronting and misrepresentation.

### **The approach to a solution**

EMPOWERMENT is a research and consultancy house that aims to research the empowerment credentials of the main active companies in the country accurately and to sell this database together with their consulting services on to their clients. A means to verify accurately and cost effectively the empowerment balanced scorecard that needs to be developed.

### **Team characteristics**

This company consists of two entrepreneurs developing the business model and a support team of four people directly involved in the implementation. The entrepreneurs are experienced in incubating start-ups, and both have M.B.A qualifications. The balance of the team is made up of experienced researchers and database managers. The framework was used as a task management tool and the researcher facilitated three iterations of the tool. Altogether 13 semi-structured interviews were conducted on this project.

### 4.3.4 A summary of the deductive projects

The salient features of the three deductive projects are summarised in Table 4.2.

Table 4.2: Deductive projects summary

Project number	Number in team	Composition of team	Number of interviews
Project 5: SOFTWARE	8	Six technical specialists, one project manager and one marketing person	19
Project 6: CAROTENE	4	One technical person, one project manager, one sales person and one production person.	18
Project 7: EMPOWERMENT	6	Two entrepreneurs, a team leader, two researchers, and two data capturers	13

The deductive projects are less focused on technical innovation and are not restricted to any particular sector in exploring the range and applicability of the framework.

### 4.3 Context summary

From the descriptions of the seven described projects, the following common elements characterise these projects. The projects are all in their early stage of development, they involve a team that is at various levels of task relevant knowledge but mostly new to the market. The innovations themselves were mostly architectural in nature, complex and mostly in the technical areas of biotechnology or information technology. If we considered Alfuah (2005) architectural innovation model as detailed below for these projects:

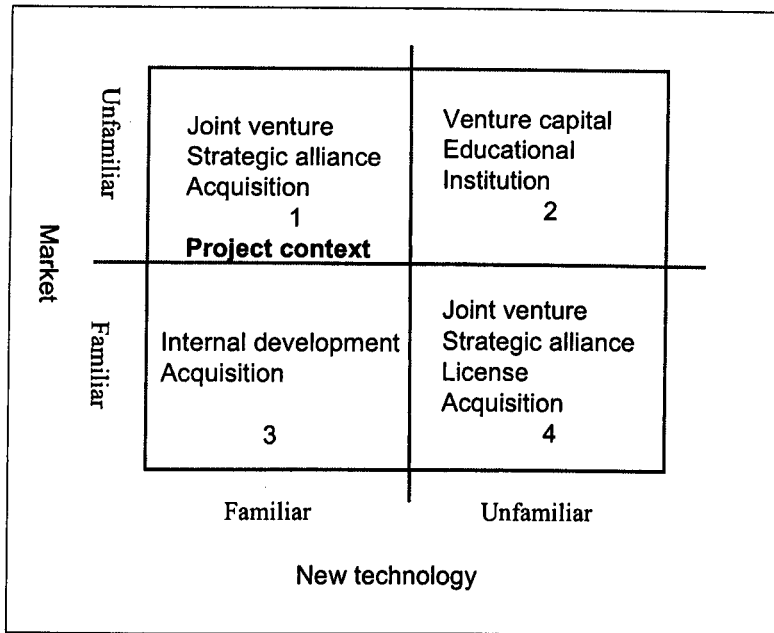


Figure 4.1 Architectural innovation model

Looking at the figure below we would hence characterise the innovation format best fitting into quadrant 1 and hence the formats of strategic alliance, joint venture or acquisition well reflect the structures in which the projects were undertaken. The reason for this relatively tight selection of the characteristics of the projects was that there was a conscious attempt to tighten out any extraneous variables that would affect the functioning of the framework.

### Conclusion

The action research method detailed in Chapter 3, when coupled with the understanding of the specific context of the projects gives the reader sufficient background to be able to understand and interpret the results which are described in the following chapter.

## Chapter 5: Results

This chapter presents a report for each of the projects, the process used, and the resulting localised insights or organisational theorising.

The original Lewinian (1973) three step process (plan, action, evaluate) was used in this chapter to present the results. The planning step involved the development of an overall plan and a clear indication of how the steps in the framework would be modified in the light of the learning's from the previous round. The action step involved the implementation of the plan with a presentation of the maps which resulted. The evaluation stage was a reflective process to establish what was learned from the action steps and to develop the basis for altering the generalised model of approach. Selected comments from the transcripts, which were most pertinent, are represented in this chapter as characterizing the patterns discerned in these evaluation processes.

These stages were repeated for each project and the headings under each project follow that structure.

### **The development of the maps:**

The maps were developed in the manner described in Chapter 3, and at the end of each mapping session the flipchart populated with ovals was transcribed into initially a "Powerpoint" electronic equivalent but by the third project specific mapping software was developed called "Axon"®, which was developed specifically to facilitate this process, but any mapping software would function as effectively. These captured maps were sent onto the team members to review and comment on. They used these electronic transcripts for communication with outside pools of knowledge and as visual reminders of the project. Some of the teams who operated in close proximity would tend to update the group map in an impromptu manner whenever something interesting happened in the development of the project.

### 5.1 Project 1: TEFLON

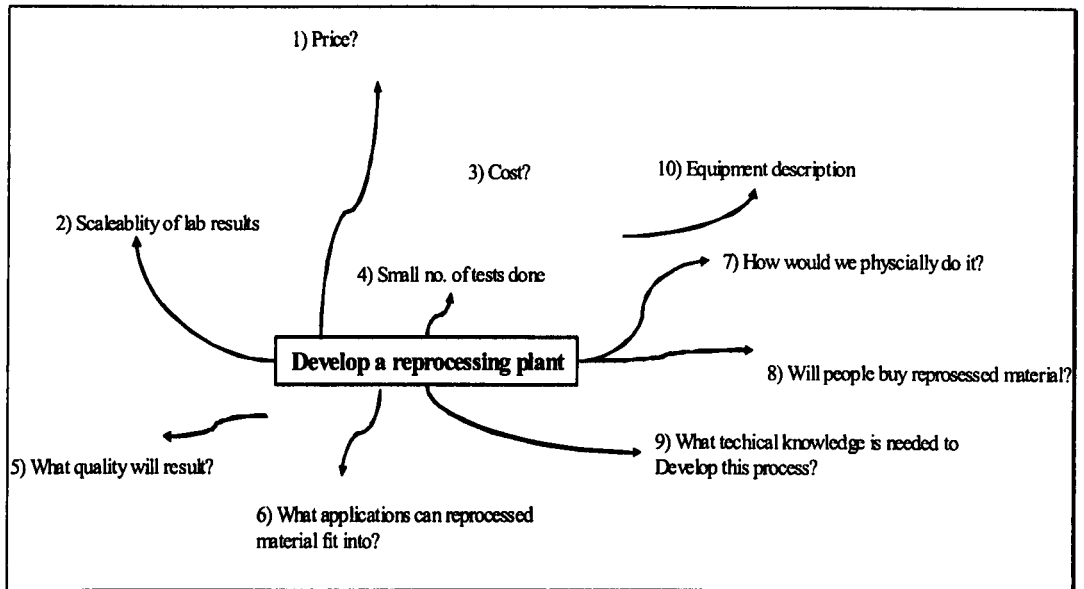
#### 5.1.1. The process planning stage

The process initial process described in section 3.6 was used on this first project.

#### 5.1.2 Cognitive map 1 for TEFLON: action stage

A first map was developed as seen in example in Fig. 5.1.

Fig. 5.1: Map 1 - TEFLON



### **Evaluation stage map 1: TEFLON**

The team members at the outset were totally new to the task and the lack of task relevant knowledge resulted in the team being unclear on the value chain, or even on what questions needed to be asked. The first cognitive map describes a large number of issues of various levels of ordinance, and while the group achieved a good shared cognition, they felt uncomfortable with developing operating concepts. The reason offered was that they were unsure whether they had identified all the key uncertainties or understood what the operating concepts represent.

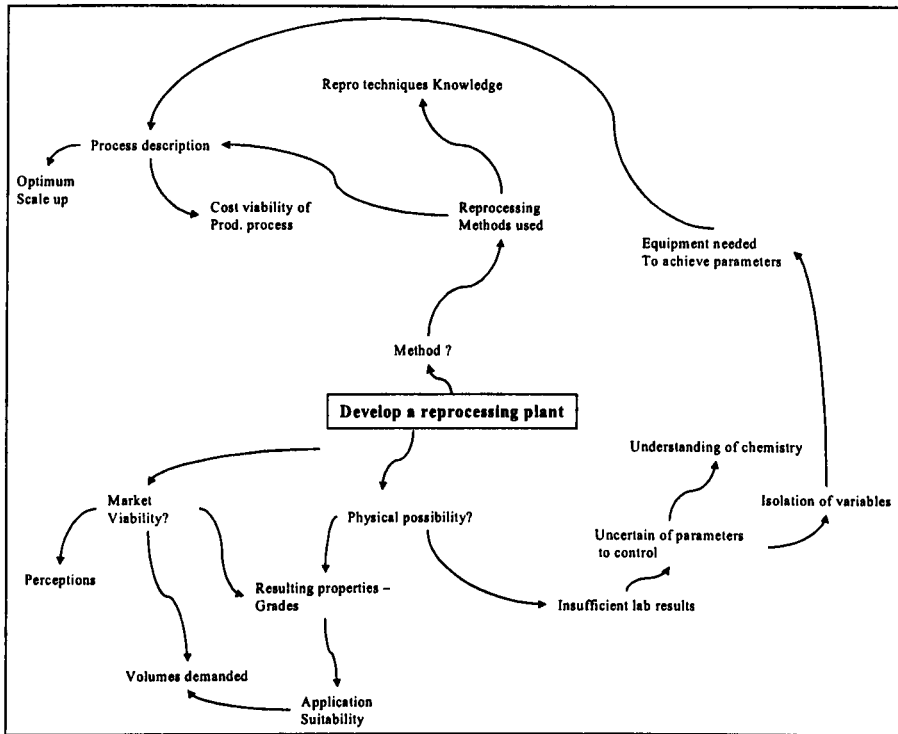
The team allocated the concepts to team members with the commitment to explore the concepts in two weeks and develop sub-maps of the issues surrounding their concepts. The group noted that the allocation of activities tended to fall into functional groupings, with the person with the most experience in the function being allocated the task. There were notable “diversions” in discussions in these early stages that seemed to revolve more around team dynamics and achieving a shared sense of the task at hand.

Over the subsequent iterations, the team seemed to become more comfortable with the process. There was a sense of exclusivity, which served to unite the group around the task but it did make obtaining support and input from the rest of the company more difficult.

#### **5.1.3 Cognitive map 2 for TEFLON: action stage**

The original map was re-mapped over several iterations around the operating concepts resulting in the map detailed in Fig 5.2 below:

Fig. 5.2: Map 2 - TEFLON



### Evaluation stage map 2: TEFLON

In the interviews between group members there appeared to be a familiarity evolving with both the process and the terminology embedded in the maps. The team members would often refer to their own sub-maps and, when questioned on the roles and responsibilities of different team members in the nature of their responses they seemed to indicate a considerable understanding of all the areas of the task.

The sub-task dependency seemed clear to the delegates and there were clear examples of the research and development team offering to the commercialisation team parameters to initiate production design at an early stage in the process. One team member commented on the level of interrelatedness evident in all the tasks, revealing a good understanding of how her actions affected the rest of the project. The team project manager seemed to feel there was a higher level of parallel processing than in previous projects, but also felt that the mapping was useful up to a point, after which

the maps seemed to become too complex or to lock in concepts which were artefacts of the process and not core to the uncertainty of the task at hand.

### 5.1.4 Explanatory effects matrix for TEFLON

The explanatory effects matrix which was described in Chapter 3, summarises the feedback from the team members indicating the effect the framework had on the themes in a 5 point Likert scale, together with comments and observations from the researcher. Not all themes were commented on. Those which were are presented in the order which they were offered.

Date: Nov 2001

Table 5.1: Explanatory effects matrix – Project TEFLON

User	User's assessment	Comment	Researcher's comment
Team leader	Neutral impact on the team roles.	<i>"The team seemed to have a problem with the lack of structure to the process initially seeking more structure than the process gives".</i>	This process is not suitable for simple tasks or for teams with low skill levels. This task is on the border of right skills band.
User 2	Effective impact on team knowledge development.	<i>"We had a process that helped us understand what questions to ask".</i>	This user (the highest skill in the group) understood the process immediately and used it to good effect.
User 4	Ineffective in developing team roles.	<i>"We are confused as to who is doing what".</i>	Throughout the process this user had a problem with the lack of structure and was always trying to bring in to do lists and linear techniques to track the task.
User 5	Very effective in task tracking.	<i>"Now I can see how what we are doing fits together".</i>	Evidence of an understanding of the interrelatedness in the task.



Team leader	Neutral view of task tracking.	<i>"I am confused, everything seems to relate to everything else".</i>	The approach of mapping interrelationships, while potentially rich in insights tends to deflect some people off the core task.
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**5.1.5 TEFLON: a summary of feedback from the use of the Skunkworks process**

A summary of the sense of the users would be that the process served to facilitate a shared cognition, while some members of the team struggled with the lack of structure in the process. It became clear that the use of the process requires expert facilitation, particularly when the team has a lower skills level. The team tended to want to inter-relate the concepts without identifying what the basis for the interrelationships. Many of the concepts offered were not well considered and fell off the map over successive iterations.

There was a need to develop a means for participants to develop their thinking, rather than being "put on the spot" as one delegate referred to the stage of offering uncertainties. One comment does deserve specific mention as it seems to encapsulate the feeling of the team generally namely "The approach is flexible, and flexibility is core in the early stages of development, however, I feel that the approach could benefit from a mechanism of idea development away from group pressures". This point was addressed through a change in the framework described in Section 5.2.1.

**5.1.6 Localised insights: TEFLON**

The company identified uncertainties that would not have surfaced otherwise. A key example was the connection between the resulting mechanical properties of the reprocessed material and the aesthetic acceptance. What surfaced quickly was that the market associated the virgin colour of bright whiteness with good mechanical properties and would not accept a muddy

white. This insight significantly impacted on the development process as the team quickly understood that the equipment had to be operated in a sterile environment and washing processes had to be developed for the raw material.

5.2 Project 2: Flavours

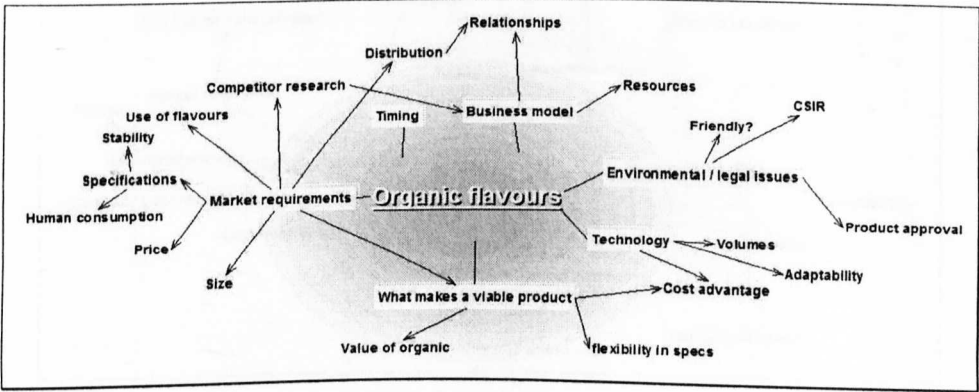
5.2.1 The process planning stage

As a consequence of the concerns raised in project one about the “ill-conceived uncertainties” that were offered, a literature review was conducted that identified the nominal group technique as a process for facilitating pre-thought on the uncertainties. This was incorporated into the process as an additional step that allowed each individual in the team to capture silently the uncertainties they saw inherent in the task. The uncertainties would then be shared amongst the team and grouped. This allowed for a more in-depth reflection unaffected by group dynamics. The balance of the process was unchanged.

5.2.2 Cognitive map 1 for Flavours: action stage

A first map was developed as seen in example in Fig. 5.3.

Fig. 5.3: Map 1 - Flavours



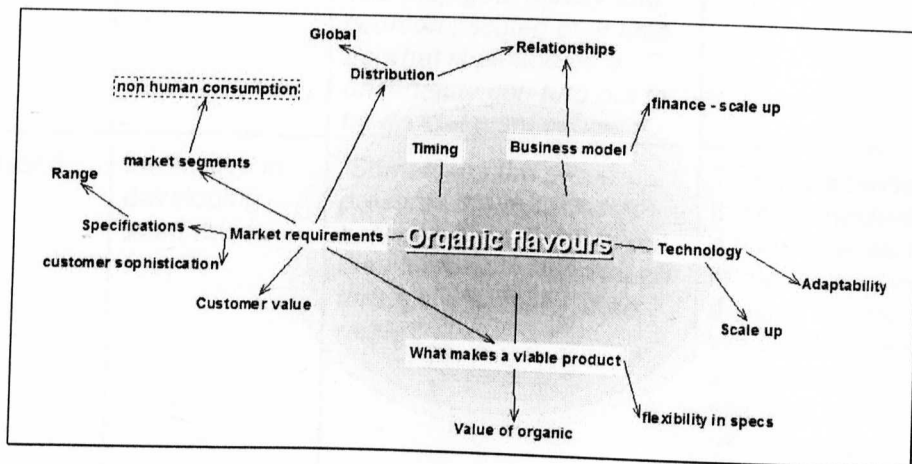
### Evaluation stage map 1: Flavours

At the outset the team displayed a polarity in knowledge with the two technology providers having been involved in the pilot from inception and being well versed in the technical aspects of the pilot production of the two test flavours as well as having done some market research initially, as they selected the two pilot flavours. The two entrepreneurs, on the other hand, were totally new to the product and market. Much of the first mapping was dominated by the technologists who used the mapping process as a way of sharing their knowledge. The lack of market understanding became apparent even in the first iteration of the map. As a consequence, many of the uncertainties were allocated to the entrepreneurs to research all the market requirements and the roles were reversed in the subsequent iterations of the map.

### 5.2.3 Cognitive map 2 for Flavours: action stage

The original map was re-mapped over several iterations around the operating concepts resulting in the final map detailed in Fig 5.4 below.

Fig. 5.4: Map 2 - Flavours



### Evaluation stage map 2: Flavours

The map in its interim versions became confusing as the group focused in the interrelationships between the concepts and consequently at a point had many concepts with more than one relationship. The group's shared understanding progressed well with the uncertainty disappearing from the project rapidly, with the resulting map in Fig 5.4 above highlighting the key underlying issue. This issue was the range of flavours the market required. The group retained the concepts well and used the map for external communication during the research.

#### 5.2.4 Explanatory effects matrix for Flavours

Date: July 2003

Table 5.2: Explanatory effects matrix - project flavours

User	User's assessment	Comment	Researcher's comment
Team leader	Ineffective in task tracking.	<i>"The tool was not clear on how the task is tracked over time as when uncertainties become certainties through actioning the events how is that indicated on the map? The map gets messy and overcomplicated over time as what is plotted as a uncertainty can turn out to be an irrelevant concept".</i>	There is a clear need to simplify how the map is handled over time. The complexity of a single map causes the team to get lost.
User 3	Ineffective in developing team roles.	<i>"Sometimes the group presents the relationship between uncertainties, but they have not often thought through why these ideas relate".</i>	There is a tendency if left unchecked for a team to assert relatedness without thinking it through. We need to create a mechanism to describe the relatedness.

## Managing innovation through cognitive mapping

Project manager	Neutral impact on teams shared cognition.	<i>"The labels sometimes while understood and agreed on but the group start to lose their shared meaning over time".</i>	There is a need to be able to capture an explanation of the shared meaning / discussion of what a label represents.
User 4	Ineffective in developing team roles.	<i>"The process proved useful in breaking down the uncertainties around the concept into workable elements that could be analysed individually to achieve measurable &amp; quantifiable results, and also highlighted issues that might not have come to the fore without the process".</i>	The team had a real sense of direction and the use of the process facilitated the correct type of questions being asked.
User 4	Ineffective in developing teams shared cognition and task tracking.	<i>"You may never get to the end of the process or too many issues could arise that may cloud or complicate and drag the process. So you need to be able to sift and only look at issues that will add value".</i>	The need for strong expert facilitation will prevent this tendency.
User 2	Very effective in developing team roles & shared cognition.	<i>"The process has resulted in a clearer understanding of the reasoning process behind innovative thinking. The group outcome is a structured, clear, graphical representation of resultant ideas, thought and concerns, which are then expanded individually giving a holistic understanding".</i>	Again the innovation component coming out.
User 3		<i>"It will take some discipline and practice to use this tool effectively and not to fall back on other more familiar methods of planning such as Work structure, breakdowns and list".</i>	The processes to use are not specific enough for use without a strong, trained facilitator.

The key reflection emerging from this project revolves around the need to gain a shared understanding of what the concepts represent and secondly to revisit the representation of the inter-relationships between concepts on the maps.

### 5.2.5 Flavours: a summary of feedback from the use of the framework

#### **Z M**

*"The process proved useful in breaking down the uncertainties around the concept into workable elements that could be analysed individually to achieve measurable and quantifiable results, and also highlighted issues that might not have come to the fore without the process".*

#### **S M**

*"My personal experience behind the Skunkworks process has resulted in a clearer understanding of the reasoning process behind effective group processes. The outcome is a structured, clear, graphical representation of resultant ideas, thought and concerns, which are then expanded individually giving a holistic understanding of the central theme of discussion".*

#### **CW**

*"The technique helped get the group into some process that would grow the shared understanding of the issues that needed to be tackled. The communication in the group as a consequence was clear and the group had a shared view. I do suggest that some means of capturing the detail of the discussion that creates the context of the label be captured as the group tends to 'forget' what was meant by a label over time".*

It was clear that the framework needed three adjustments.

1. It was necessary to capture in hard format some of the richness of the discussion as over time the shared understanding and view of the different concepts tended to dissipate. Different methods were tested with the most favoured being capturing on the back of the post-it that represents the concept some of the discussion, relevant points and understanding relating to that concept.
2. The issue of indicating relatedness was reviewed and, while a cognitive mapping can yield rich insights if correctly used, it seems that the main objectives of the framework could be achieved with a hierarchical mapping rather than focusing on relatedness.
3. The operating concepts were not easily managed and needed to be specifically defined for each project. A process was needed to assist the team in identifying the operating concepts.

### **5.2.6 Localised insights: flavours**

The market uses a number of flavours, and will only see organic flavours as a significant advantage if they have the most common ones available in the organic format. This would enable them to market accordingly. This insight resulted from the parallel exploration of both the marketing and research functions. This difficulty ultimately lead to the demise of the project, but the early identification of this issue helped save the company money on sunk costs it would have otherwise incurred.

## **5.3 Project 3: Fish**

### **5.3.1 The process planning stage**

There was a need to address the two key learning points from the last project namely the need to achieve a shared understanding of the concepts and to revisit the representation of the inter-relationships between the concepts, as

they seemed to confuse the team. The process was modified in the way described below.

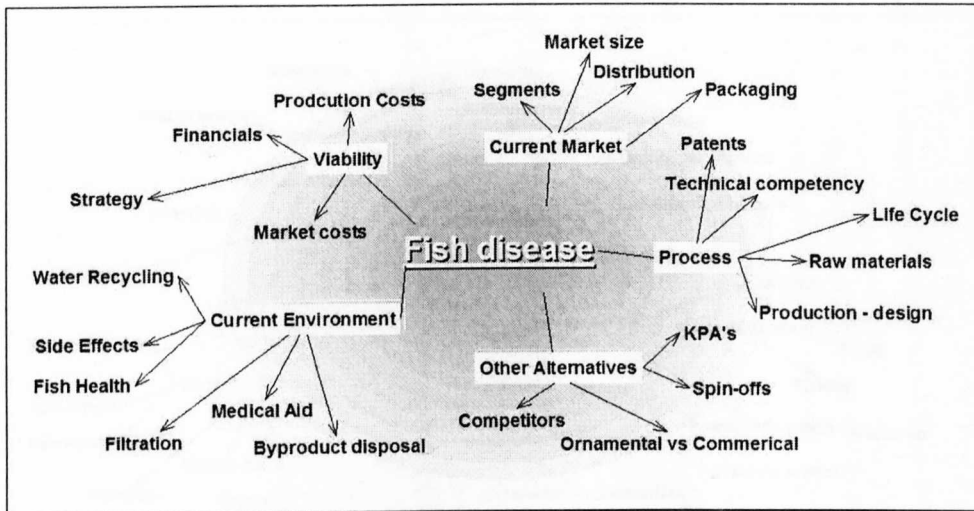
- 1) After the individuals capture the uncertainty, they record on the back of the card a short description of what is meant by that uncertainty.
- 2) In this project the focus was shifted to the hierarchical representation of the relationships rather than the interrelatedness between the relationships. While some richness will be lost as a consequence it was expected that the process would be simplified. Where there is specific obvious interrelatedness between concepts the facilitator will tease this out, normally once the map is nearing completion for that iteration. This helps to define sub-task interdependence and this assists in the allocation of the events to the correct member/s to explore.
- 3) A divergent brainstorming process of offering all the uncertainties possible and thereafter grouping, discarding and hierarchical sorting was introduced.

### 5.3.2 Cognitive map 1 for Fish: action stage

A first map was evolved as set out in example in Fig. 5.5.



Fig. 5.5: Map 1 - Fish



### Evaluation stage map 1: Fish

This team had the advantage of all members having had some exposure to either the technical or marketing aspects of this task. They were a senior team who knew each other and were all commercially committed as stakeholders in the project. The motivation in the team to succeed was high. The team devoted a significant time (6.5 hours) to the first map, with a good portion of the time spent on divergence to dig out all possible uncertainties. Some uncertainties that surfaced were debated at length and ultimately discarded. The team very quickly achieved a good shared cognition and evidenced natural close and easy communication.

### 5.3.3 Cognitive map 2 for Fish: action stage

The original map was re-mapped over several iterations around the operating concepts. A middle map is detailed in Fig 5.6 below.



## Managing innovation through cognitive mapping

### 5.3.4 Explanatory effects matrix for Fish

Date: August 2003

Table 5.3: Explanatory effects – project fish

User	User's assessment	Comment	Researcher's comment
User 5	Very effective impact on TRK.	<i>"Measuring my knowledge about the idea when started, against my knowledge now after the Skunkwork process is as different as day from night. I feel that I have a firm grip around the idea. The amount of time spent to reach this state of mind was minimal. At last a tool to cross the abysses of good ideas".</i>	Refers to efficiency in the acquisition of the task relevant knowledge.
User 2	Very effective impact on TRK and team roles.	<i>"By laterally writing down all the uncertainties which came to mind when we were doing the Skunkworks and grouping it down to Legal, which I was assigned to do, marketing, manufacturing, supplier, delivery channels and customers, I ended up having a vivid picture of our requirements. The only suggestion would be to explore a neater way of capturing the action required".</i>	This need to represent the action and associated responsible person better, was a constant theme throughout the interviews.
User 3	Very effective impact on team creativity.	<i>"The freethinking environment provided by this methodology allows the innovator to think outside the box".</i>	Clear evidence of the value of divergent processes.
User 4	Very effective impact on TRK and team creativity.	<i>"Using Skunkworks we were able to learn more and more issues around the product that were investigating. We found that some ideas that we generated were quite innovative. I have already started using Skunkworks in my everyday life and find the process greatly enhanced idea generation".</i>	Again a strong reference to the creative elements of the tool.

**Managing innovation through cognitive mapping**

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User 1	Very effective impact on TRK and team creativity.	<i>"I was following a system which reassured me that my freedom was controlled in an organised manner. It has been said that one of the greatest gifts a person can have is to come up with ideas, and the Skunkworks helps achieve creative ideas".</i>	As comment above.
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**5.3.5 Fish: feedback from the use of the Skunkworks process**

**W.M**

*"There was a lot of uncertainty concerning this product in the legal aspect of the technological knowledge or market knowledge and the capabilities we had as a newly formed organisation. We had no clue of what competences and endowments we had, especially to have a feel of what type of innovation we were faced with. Were we faced with incremental, architectural or radical type of innovation to deliver this product to the market? We had no clue of what legal requirements are needed to protect the competences and endowments of the firm when developing this product and commercialising it. All these uncertainties became clearer when we started doing our Skunkworks. After we finished with our Skunkworks, I learned the following:*

- value proposition definition and we were able to test and learn any environmental issues regarding our innovation;*
- the Skunkworks process was very quick and flexible and gave us more insights."*

**T.C**

*"I had always found brain storming to be something of a difficult exercise. When using the Skunkworks method, I found that it was very easy to generate lots of ideas. For me, the major hindrance to the generation of ideas was that I would constantly try to analyse the ideas that I was thinking of rather than concentrating on the idea generation process. Skunkworks taught me that*

*there is no such thing as a dumb idea. One just has to write down all those ideas that come to mind."*

### **H.P**

*"When tackling a project of this size and magnitude the Skunkworks helps find a place to start, and from that point ideas flow. The Skunkworks gave me direction to my area of research, which is competitors and distribution. All relevant information was put on paper and at times one cannot write fast enough, being afraid that some ideas or information will be lost. This is good in the sense that one would rather have lots of information and ideas, than battle to find information or where to start putting information to paper. I found that when doing my Skunkworks, I felt free to write down whatever came to mind and didn't feel restricted which in turn allowed me to give ideas which in the beginning I would never have thought of, and these ideas in turn sparked off other ideas and areas of thought".*

Because they had stronger facilitation, the participants did not have to focus on the process and the inter-relationships between the concepts, and this allowed the group enough time for the divergent components, and thus a higher level of creativity was in evidence throughout the process. The approach of introducing brainstorming techniques into the process significantly changed the texture of the experience and resulted in a wider view of the possible uncertainties and the development into two distinct market segments (ornamental and edible) simultaneously. The divergent processes noticeably increased support from the team.

### **5.3.6 The localised insights: Fish**

The strong divergent processes allowed a broader scanning of the environment and as a consequence the early "discovery" of a parallel market emerged that could be exploited.

### 5.4 Project 4: Skin

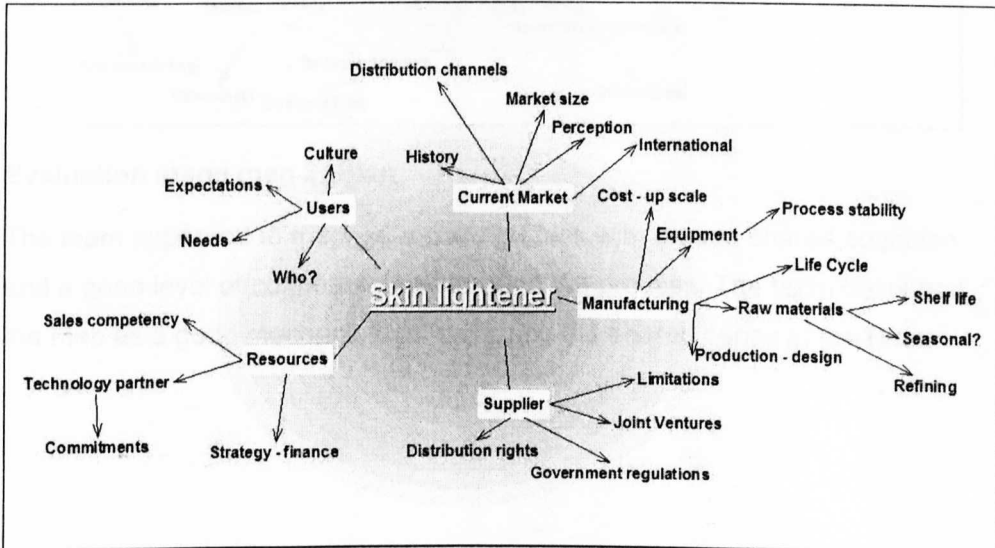
#### 5.4.1 The process planning stage

The feedback from the last inductive project appeared to indicate that the right balance between a flexible simple process, with clear facilitation to enable the divergent stages, seemed to create the right balance. The only changes to the process that seemed sensible revolved around clarifying the issues that required action, as there was a risk that these might be lost in a complex map. It was suggested that at the back of these concepts, the required action and responsible person be noted.

#### 5.4.2 Cognitive map 1 for Skin: action stage

A first map evolved as seen in the example in Fig. 5.7.

Fig. 5.7: Map 1 - Skin



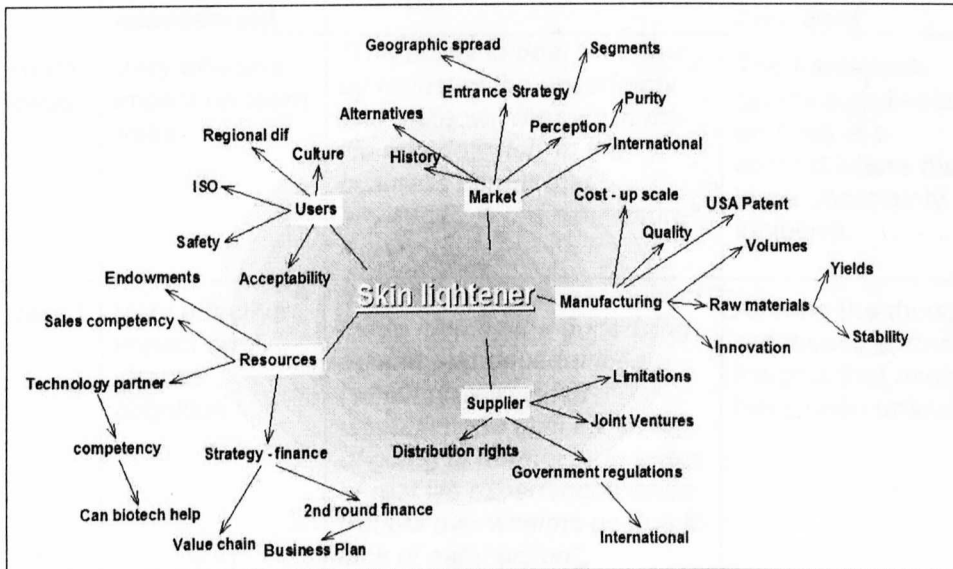
#### Evaluation stage map 1: Skin

The facilitator played a strong role in the development of this first map to ensure the right balance between divergent and convergent processes, which yielded a rich mapping with strong support from the team.

### 5.4.3 Cognitive map 2 for Skin: action stage

The original map was re-mapped over several iterations around the operating concepts. A middle map is detailed in Fig 5.8 below.

Fig. 5.8: Map 2 - Skin



### Evaluation stage map 2: Skin

The team appeared to manage a complex task with a good shared cognition and a good level of communication through the process. The team described the map as a good mechanism for capturing the shared sense of the task.

### 5.4.4 Explanatory effects matrix for Skin

Date: October 2003

Table 5.4: Explanatory effects - Project Skin

User	User's assessment	Comment	Researcher's comment
Team leader	Very effective impact on team roles.	<i>"The ability to deal with fear by reducing the uncertainty and unknown themes in my life and definitely in the business career that envisaged in the near future".</i>	The framework clearly supplies a process in a context where the large uncertainty is inhibitive.
User 1	Very effective impact on shared cognition.	<i>"I felt that the process helped me to identify the underlying doubts and uncertainties (which usually is left unchallenged until the point of going to market or in terms of real life experiences when trouble overwhelms us due to lack of early action".</i>	Altering the thought process to surface insights that might have been unsaid.
User 3	Very effective impact on team roles and task tracking.	<i>"The Skunkworks helps find a place to start, and from that point ideas flow. The Skunkworks gave me direction to my area of research, which is competitors and distribution".</i>	By providing a starting point and a process, people feel at liberty to express their ideas.

### 5.4.5 Project Skin: feedback from the use of the Skunkworks process

C.H

*"It has been said that human beings are only afraid of the unknown. Once familiarity sets in on any given unknown theme, fear dissolves very quickly. It is facing the unknown themes head-on and dealing with them that gives one confidence and hence the appearance of bravery. Skunkworks is the tool that I have been seeking for a long time to apply to my daily life, work and business routines".*



### **B. M**

*"The Skunkworks process proved to be a very useful tool for mapping all the issues relating to a certain problem. The guidelines for performing Skunkworks were interesting in the sense that the output of the Skunkworks had a lot more ideas written down as a result of the methodology. The freethinking environment provided by this methodology allows the innovator to think outside the box. All ideas generated are regarded as useful and the breaking down of each idea ensured that sub-attributes of an idea are followed to the end".*

It is clear that the stronger role played by the facilitator created a more positive platform from which the framework can operate and there tended to be high energy levels in the process, with a lower tendency towards artefacts and superficialities.

### **5.4.6 The localised insights: Skin**

This was a complex multifaceted project with high levels of uncertainty in all the stages of the value chain. Through clear facilitation, sufficient air time was allowed for the divergent processes associated with the brainstorming stages. All components of the value chain were focused on which resulted in a rich view of all these aspects by the third mapping. Consequently the development path progressed smoothly and was completed under time and under budget.

### 5.5 Key insights from the inductive rounds

The approach has changed between the first and fourth project essentially from a stand alone set of fixed steps to a few principles that should be followed under clear facilitation. Most of the localised insights resulted from the parallel development of all the uncertainties associated with all stages of the value chain. The table below summarises the findings from the inductive rounds.

Table 5.5: A summary of the learning from the inductive rounds

Project	Themes	Localised insights	Changes to process
1. TEFLON	The process suits high complexity. Difficult to work with the operating concepts.	A broader view of the uncertainties in advance.	Include the nominal group technique to facilitate individual reflection.
2. Flavours	Unclear relatedness between concepts. Difficult to retain meaning of concepts over time. Still struggling with the operating concepts.	Parallel processing of all stages of the development cycle	Changed to a hierarchical form of cognitive mapping Capturing issues related to concept on the back of the concept card. Adding brainstorming processes to evolve operating concepts.
3. Fish	Better levels of energy and creativity.	Identified a new potential market very early on.	Add responsibilities and due dates on the back of the concept card.
4. Skin	Stronger facilitation creates positive momentum, with fewer artefacts.	Smooth efficient path of development – under time under budget.	Ensure the facilitator plays a stronger role.

The feedback from the interviews was summarised into the time ordered explanatory effects matrix in Table 5.6.

Table 5.6: A time ordered explanatory effects matrix of the inductive rounds

Project number																					
Variable / Time period number		1				2				3				4							
1) <b>Communication:</b> Evidence of a common vocabulary Evidence of misunderstandings. Use of map for external communication	++ + 0 - -	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5
2) <b>Creativity:</b> Evidence of associative thoughts being included & periods of divergent processes	++ + 0 - -																				
3) <b>Task relevant knowledge:</b> Does the map represent everything you know? Do you know what you don't know? Accuracy in developing task relevant knowledge	++ + 0 - -																				
4) <b>Team roles:</b> Do you know who is doing what? Evidence of duplication of work	++ + 0 - -																				
5) <b>Tracking:</b> Evidence of the use of other tools. Time spent on tracking	++ + 0 - -																				

The observations from the time ordered explanatory effects matrix are presented below.

- The communication in the team improves over the life of the project, which is to be expected even without the use of the framework, as the team normalises and develops effective routines to support communication. The trend is generally upward across the projects indicating that the framework has had some effect on the communication and shared cognition in the teams. There were mixed findings on effectiveness of the framework in communication outside the team, as it seems that the parties needed to be privy to the discussions to fully understand fully what the map represents.
- The capturing of the understanding on the back of the concept card corresponded to higher levels of communication or shared cognition, however, capturing the roles and responsibilities in the team did not seem to have a strong impact on task relevant knowledge
- There was a step change in the experience of the participants after the second project. This is attributed to the three extra components added to the framework. Creativity revealed the greatest change as no real process was in place to manage divergent processes prior to adding the brainstorming process. The nature of the group dynamics even changed after including the divergent processes. The team appeared to take the issues to heart more strongly and high levels of ownership were in evidence.
- The creativity dimension shows the strongest improvement over the projects and, relative to the other dimensions, is the highest scoring. This suggests that the framework has a positive effect on team creativity which is supported by the comments made by the team members.

- The task relevant knowledge generally seems to follow a convex shape, indicating that the framework is best at holding the task relevant knowledge in the middle of the process but seems to drop off at both ends. The drop-off on the end of the process is easy to explain, as the project knowledge tends to deepen and become more specific as time goes on and the framework is clearly not intended to function too far into the project. It is anticipated that a slow but continuous drop-off in the task relevant knowledge would occur if the framework were to be used outside the area for which it was intended.
- The team roles also suffer from the same effect; the roles become increasingly complex over time as outside business linkages and resources are brought to bear. The trend in the team roles over the projects is not clear in the inductive rounds as it appears to be relatively flat.
- The tracking (as defined as a clear allocated locus of responsibility, coupled with a directed development as defined in detail in Appendix A.3), is one of the weakest dimensions, as it shows relatively no improvement over the projects and, relative to the other dimensions, is one of the lowest scoring. This does imply that the framework has not had a strong positive impact on the task tracking. This could be attributed to the fact that the tool focuses only on the areas that are uncertain in the project and does not bring into the map the areas in the task where the team might be certain, but which still do require action or project management.

This foundation of data and understanding, which resulted in the final form of the framework, was carried into the deductive rounds, the results of which follow.

### ***5.6 The deductive rounds, process planning***

#### **The process followed**

The same process was followed throughout the deductive rounds, which had evolved in the inductive rounds from the initial process which was described in Chapter 3.6. The final process is summarised below.

**Preparation:** An effort should be made to collect any background information task descriptions, aims and objectives to support an understanding of the task. This information should be disseminated and read prior to the first meeting.

#### **Step 1 - Capturing the task** (oval mapping technique (Eden et al., 2002))

The task should be described on the front of an oval Record Card and placed in the centre of a large page. Some time should be taken to ensure that the team has a shared understanding of what the task is. The detailed task description in terms of deliverables, expectations, and limitations should be described and agreed on at this point. This should be recorded and captured on the back of the oval Record Card. It is crucial to have a rich shared understanding of the task before proceeding.

#### **Step 2 - Generating uncertainties** (Delbecq et al., 1975)

Each individual in the group silently generates concepts that in their view represent uncertainties about achieving the task. The group member should write each of them down on a separate Record Card with a detailed description of what is meant by that concept captured on the back of the oval Record Card.

#### **Step 3 - Capturing and grouping uncertainties** (Corti et al., 2000; Eden, 1992; Huff et al., 2002)

The group members engage in a round-robin feedback session to record each uncertainty around the task concisely. Clear duplicates can be eliminated as

they are mapped around the task. Each uncertainty is discussed, so that the team has a shared cognition with the originator. If an uncertainty is offered by a member which is a certainty to another member, an explanation should be provided so that this concept becomes a shared certainty within the group. If the round-robin process prompts new trains of thought causing new uncertainties to surface they should be recorded in a like manner on the oval Record Cards. Time should be taken to brainstorm even peripheral "uncertainties". Once all the uncertainties are presented they should be grouped into clusters that share evidence of relatedness between the uncertainties. Three to five broad clusters of concepts normally evolve. Suitable descriptors must be assigned to each grouping on the front of an oval Record Card, with a description on the back of the same oval Record Card detailing what the group understands by that descriptor. Henceforth these descriptors assigned to the groups will be called operating concepts.

### **Step 4 - Mapping from operating concepts down to events (Rugg (1995);Eden et al., 2002).**

Each operating concept has an uncertainty of actualising as one is dealing with future events in an uncertain environment. Sort the underlying concepts around each of the operating concepts, which further detail the uncertainty represented in the operating concept. These subordinate concepts will be represented both by the uncertainties previously brainstormed as well as other concepts that might have surfaced in the interim. Arrows must be added from the originating concept to the concept a level below. These arrows indicate a cognitive relatedness rather than causality.

The process is repeated, with each subordinate concept drilling down until the group cannot develop a more detailed uncertainty at that point in time. The subordinate concepts at the bottom of the resulting chain represent the most detailed descriptions of the uncertainty in the team's task relevant knowledge at that moment.

### **Step 5 - Allocating uncertainties (Corti et al., 2000)**

The subordinate concepts at the bottom of the chains will represent one of two positions.

- The concepts are not highly detailed and will suggest an area of low task relevant knowledge. For these concepts the group must assign responsibilities on the back of each oval Record Card detailing who must research that uncertainty within a time frame in order to develop the task relevant knowledge in this area.
- The concepts are detailed and represent a very precise definition of the uncertainties. These concepts are called events as the group is clear on what actions need to be undertaken to eliminate the uncertainties. At this point the subordinate concept is no longer an uncertainty and can be rephrased on the back of the oval Record Card as an action item and drawn into traditional project management tools such as Gantt charts.

### **Step 6 - Growing the team's task relevant knowledge (Collison et al., 2001)**

In the intervening period between formal meetings of the team to update the group map, individuals will be exploring the areas in which they have been allocated uncertainties. Individuals should endeavour as far as possible to access specialist knowledge resources that might rapidly be able to develop the required task relevant knowledge. Frequently sub-maps can evolve as individuals explore these areas, which can be useful in communicating back to the larger group. An effort should be made to hold discussions with other team members who had been allocated related areas of task relevant knowledge to explore.



### **Step 7- Updating the team map** (Collison et al., 2001, Frederiksen et al., 1989)

The group should meet regularly in order to update the group's shared knowledge. The large group map must be updated to reflect the most current shared understanding of the group. Time must be allowed for each team member to share the new task relevant knowledge that has come to light as a result of their actions in the intervening period.

If uncertainties are resolved, they can be deleted from the map and if new uncertainties surface, they should be added to the group map. The detail captured in the sub-maps of specialist areas need not be captured in the main map, unless this contributes to the shared understanding of the team. The frequency of these meeting will depend on the nature of the task and should be set by the team leader. The number of iterations of the group map will depend on the nature of the task and needs of the group. The process should continue until the group members no longer see a need for the process.

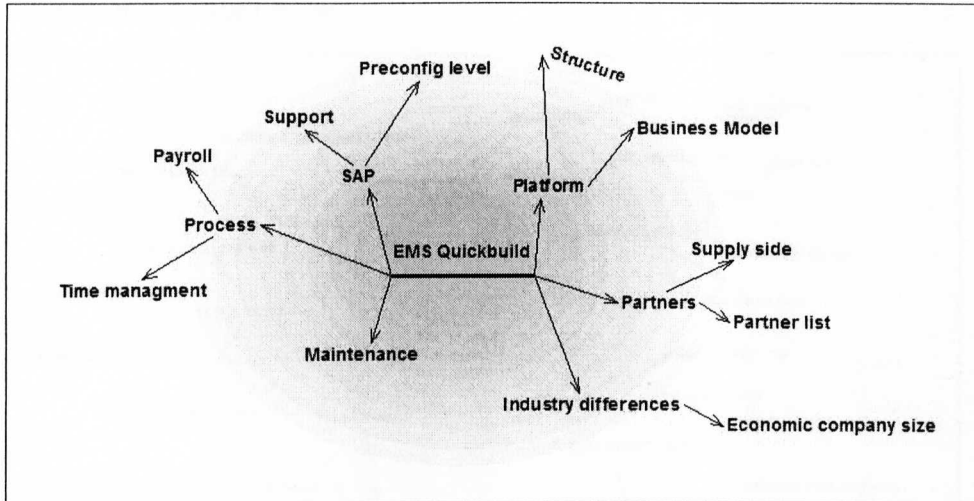
Facilitator's notes to assist facilitators in the use of this framework and basis of derivation are offered in Appendix A.1.

## **5.7 Project 5: SOFTWARE**

### **5.7.1 Cognitive map 1 for SOFTWARE: action stage**

A first map was evolved as set out in example in Fig. 5.9.

Fig. 5.9: Map 1 - SOFTWARE



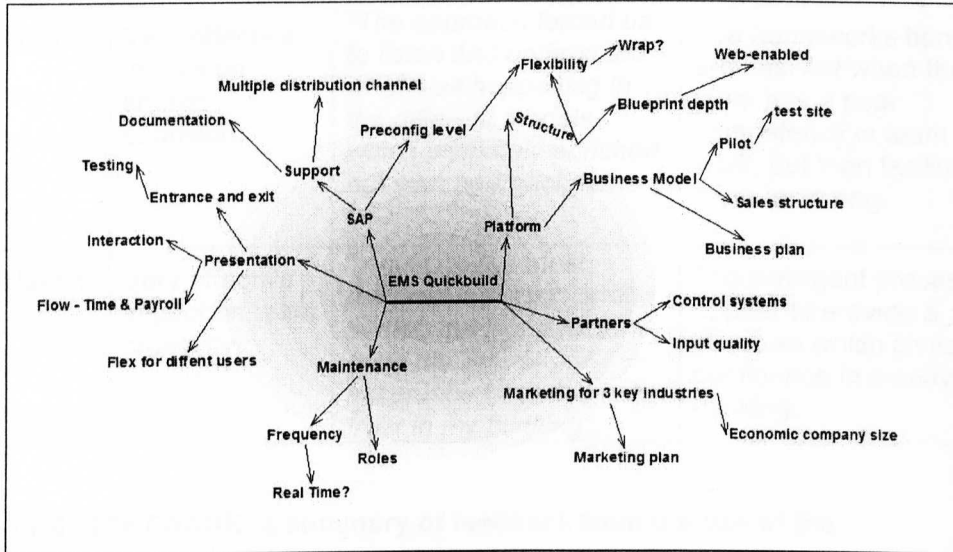
### Evaluation stage map 1: SOFTWARE

The team consisted largely of a number of technical experts, who had little or no understanding of each others areas. There was a strong need to pool and integrate the expertise for the benefit of younger learners coming through the company, so the team was highly motivated but not the best profile of persons for team work. The members of the team had worked in the same company for a number of years, so they knew each other well and quickly settled into the task. The team had a strong tendency to converge and a tendency to want to divide the tasks into clear separate subtasks which each team member could quietly effect on their own. After four hours of mapping the above map represented a good shared sense of what the operating concepts were and the uncertainties associated with them.

### 5.7.2 Cognitive map 2 for SOFTWARE: action stage

The original map was re-mapped over several iterations around the operating concepts. A middle map is detailed in Fig 5.10 below.

Fig. 5.10: Map 2 - SOFTWARE



### Evaluation stage map 2: SOFTWARE

The complexity of the map was easily managed by the team through the following mechanism: allowing issues that were uncertainties in earlier maps, but which had been resolved not to be presented in subsequent maps, which is what many of the other projects were informally starting to do. With this approach the final map at the end of a successful project would be blank, as there would be no associated uncertainties. One is not able to monitor the actions and what is known on the project, but it has the advantage of clarity and focus.

### 5.7.3 Explanatory effects matrix for SOFTWARE

Date: November 2003

## Managing innovation through cognitive mapping

Table 5.5: Explanatory effects - project SOFTWARE

User	User's assessment	Comment	Researcher's comment
User 2	Very effective impact on shared cognition.	<i>"The approach forced us to listen and understand what was happening in the different models, which ultimately enriched our own approaches".</i>	The frameworks benefits are best felt when the team has a poor competency in team work, but then facilitation must be strong.
User 1	Very effective impact on team creativity.	<i>"I must be the most uncreative person on the planet, but this structure gave me the re-assurance I needed to be freer in my thinking".</i>	The divergent processes appear to provide a structure which gives confidence in creative thinking.

### 5.7.4 SOFTWARE: a summary of feedback from the use of the Skunkworks process

*"It was great to be able to share the progress made and get input from informed peers who could still see the wood from the trees. There is almost a type of team mentorship role that comes into play in the feedback stages".*

It is a common feature in the re-mapping or feedback processes that more uncertainties were offered by other team members which had the effect of getting input on your components from someone who was informed in the project but not too close to not see the uncertainties. There is a marked weakness in projects where people are either informed and are so close to the project that they have a cognitive bias, or people are uninformed and hence cannot meaningfully contribute.

### 5.7.4 Localised insights: SOFTWARE

The team achieved two significant advantages through the use of the process.

## Managing innovation through cognitive mapping

- The team was able to gain a deep sense of the market requirements in advance and design the tool around the requirements of those three industries.
- The team was forced to maintain a shared view of the development process which was crucial both to the seamless integration and consistency of presentation across the different modules, as well as to ensuring that their understanding of the other module would be sufficient to use the tool in areas outside their competency.

### 5.8 Project 6: CAROTENE

#### 5.8.1 Cognitive map 1 & 2 for CAROTENE: action stage

In order to illustrate the grouping process is presented below as follows.

Fig. 5.11: Map 1 CAROTENE

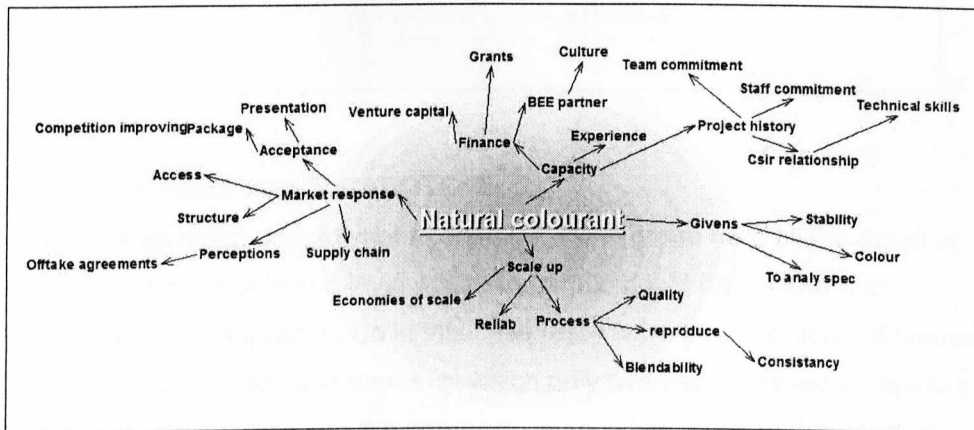


#### Evaluation stage map 1: CAROTENE

This ungrouped view of the concepts was developed through two hours of mapping. This view was offered to provide some insight into the depth of

divergence that is needed to develop the operating concepts. The 46 concepts represented above represented only a fraction of the concepts which were offered, discussed and ultimately rejected. The mapping above would next be grouped and drilled down into a hierarchical representation which would also allow further concepts to surface. A first hierarchical mapping of the concepts is presented in Figure 5.12.

Fig. 5.12: Map 2 - CAROTENE



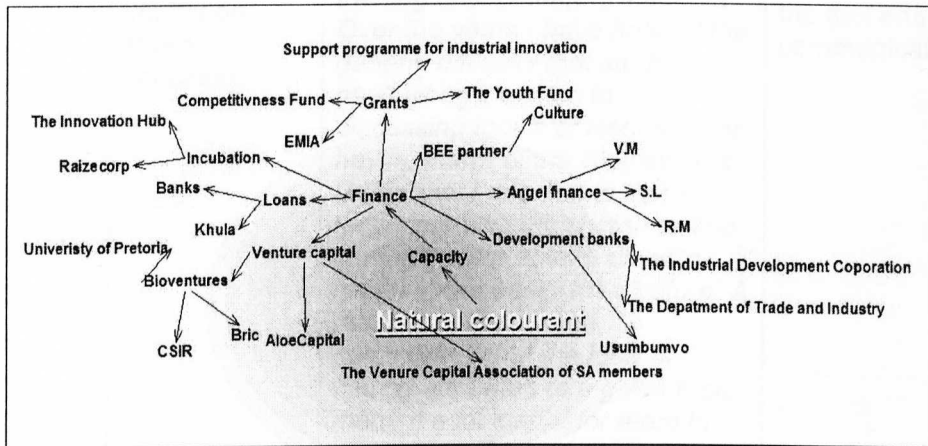
### Evaluation stage map 2: CAROTENE

In the subsequent maps, as new uncertainties surface they are added and most sub-maps tended to develop project specific operating concepts which supports the move away from the standardised product development chain based operating concepts.

#### 5.8.2 Cognitive map 3 for CAROTENE: action stage

A sub-map of the finance operating concept (which proved to be a fatal uncertainty in this case as the Black Economic Empowerment partner originally identified as the source of project finance did not deliver) is detailed in Fig 5.13 below.

**Fig. 5.13: Map 3 - CAROTENE**



### Evaluation stage map 3: CAROTENE

It became common practice not to describe in the group map all the detail of the sub-maps but only to a level where the group could have input and contribute to the approach. So in this case there were three sources of finance grants, venture capital and banks, of which only two were pursued as options and hence represented into the aggregate map, while much of the detail of the sub-map was discussed in a plenary session, the detail of who specifically was being approached was not presented in the aggregate map.

### 5.8.3 Explanatory effects matrix for CAROTENE

Date: May 2004

Table 5.6: Explanatory effects - project CAROTENE

User	User's Assessment	Comment	Researcher's Comment
User 1	Very effective impact on task tracking and team roles.	<i>"The parallel development of all uncertainties helped us to realise early on that the sourcing of finance was make or break and to establish that in our case it was probably a theme that would cause failure unless we secured off take agreements".</i>	It seems that in most developments the forced parallel development is a good feature of the framework.

## Managing innovation through cognitive mapping

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User 3	Very effective impact on shared cognition.	<i>"My work involves the periodic training of engineering students. Over the years I have noticed the general difficulty that students have when it comes to discussing topics or issues. After having learnt of the Skunkworks technique, I decided to try the technique with my students. The students were able to discuss issues more easily than before. A number of them even commented that the idea of finding attributes of a given topic made it a lot easier for them to discuss any topic".</i>	A clear reference to the tool enabling communication.
User 4	Very effective impact on shared cognition.	<i>"I had a clear view of the groups thinking, so that as I needed to adapt my uncertainty with new information coming to light, I was able to do so independently".</i>	This highlights relatedness between shared cognition and task roles.

### 5.8.4 CAROTENE: a summary of feedback from the use of the Skunkworks process

It was interesting to note that during a five month period of contact with CAROTENE for this study most of the team members who were engineering consultants used the tool in their projects with their clients indicating that they believed the tool has a good utility.

### 5.8.4 Localised insights: CAROTENE

The forced parallel development caused the team to identify the criticality of two dimensions, the need to identify and secure finance for the project and secondly to strengthen the supply channels and relationships. These two areas were related and ultimately it became clear are mutually related with the capacity to secure finances in a bridging capital contact being dependent on off-take agreements or contracts with clients.

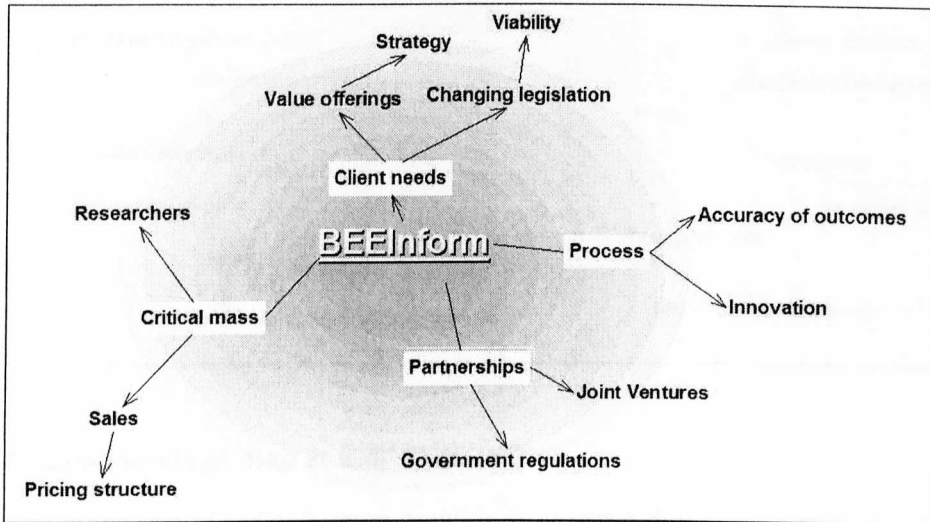


## 5.9 Project 7: EMPOWERMENT

### 5.9.1 Cognitive map 1 for EMPOWERMENT: action stage

The first cognitive map is presented below in Fig 5.14 as follows.

Fig. 5.14: Map 1 - EMPOWERMENT



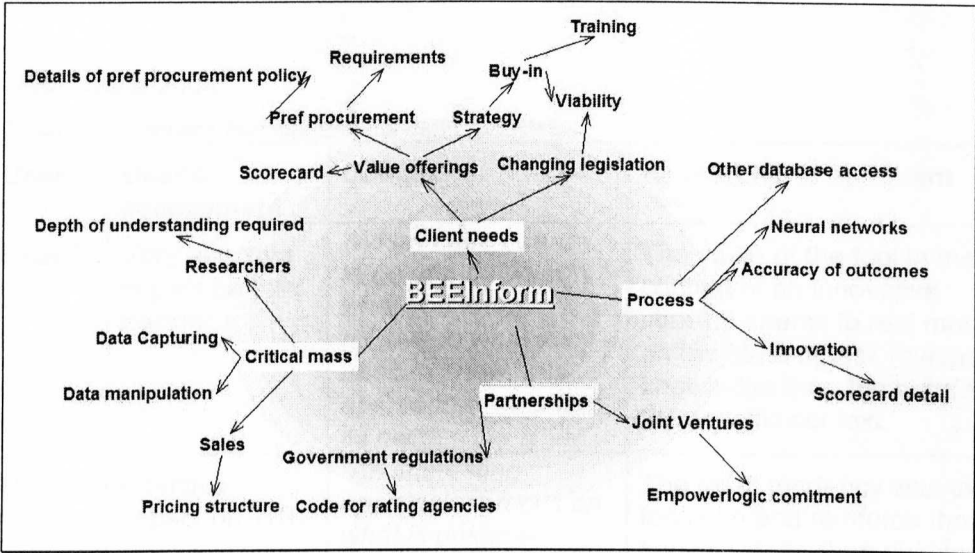
### Evaluation stage map 1: EMPOWERMENT

There were 64 uncertainties which could be grouped clearly into four simple operating concepts that became guiding principles in the business. These operating concepts embedded into the fabric of the project and were used to guide decision-making in the business.

### 5.9.2 Cognitive map 2 for EMPOWERMENT: action stage

The original map was re-mapped over several iterations around the operating concepts. A middle map is detailed in Fig 5.15.

Fig. 5.15: Map 2 - EMPOWERMENT



**Evaluation stage map 2: EMPOWERMENT**

The maps varied radically from iteration to iteration due to the rapid development of the task relevant knowledge, and the rate of change of the underlying client needs. The value of this process in such a fluid environment became evident and the team was committed to the ongoing use of the approach in order to ensure symbiosis with the environment of business was maintained, as the nature of this task was less closed-ended than other tasks.

### 5.9.3 Explanatory effects matrix for EMPOWERMENT

Date: June 2004

Table 5.7: Feedback from participants EMPOWERMENT

User	User's assessment	Comment	Researcher's comment
User 3	Very effective impact on task tracking.	<i>"When there is a large gap between what you know relative to what you need to know, this approach comes into its own".</i>	The value of the tool in the context of an innovative start-up seems to rest more on the state of task relevant knowledge than the nature of the specific context.
User 1	Effective impact on TRK.	<i>"An interesting approach to focus on what is unknown versus what is known".</i>	The team tendency was to focus on and reinforce the known rather, than pushing the boundaries of the unknown.
User 4	Effective impact on TRK.	<i>"I found myself offering solutions that I could have not found on my own".</i>	Evidence of group problem solving through reframing and problem wideness.
User 2	Very effective impact on TRK.	<i>"I can see many versions of this framework applying to different aspects of our operations or those of our clients".</i>	It would be interesting to see how this framework could be adapted to strategic thinking.

### 5.9.4 EMPOWERMENT: a summary of feedback from the use of the Skunkworks process

As a researcher it was interesting to observe the framework applied by a team with rich management experience (based on the number of years in management and nature of the management responsibility), as they immediately seized upon the approach as a mechanism to help the business to re-frame itself constantly. There was not a need for much strong facilitation and there was a greater level of exploration around the possibilities of the framework itself as a tool in the company's consulting on strategy. The concepts presented were not manifestations of team dynamics or current low

level issues but tended to represent rich insight into the heart of the business. Based on the experience with this team, it would appear the approach has a greater value in more senior teams. Most of the team members adopted the approach in their daily activities, and different versions of the approach started to manifest themselves over the three month period.

### **5.9.5 Localised insights: EMPOWERMENT**

Based on the experience of this framework the group has an approach to constantly re-evaluate their value offering in the light of the needs in a fluid business environment. The approach helps the team not to lock into one business model but constantly to re-evaluate their value offering in the light of the needs of the market. The team debated the relationship between the operating concepts which provided some interesting insights and the operating concepts strung into relationship to each other yielded some rich insights into the purpose of the business, which was distilled into "research once, on-sell many times".

The relationships between ensuring that the focus and nature of the task were appropriate appears to be an interesting area for future research as it was apparent in most of the projects that the team did not have a clear understanding of the purpose of the task at the outset.

### ***5.10 Key insights from the deductive rounds - summary***

The different themes running through the projects together with their corresponding localised insights are represented in Table 5.8.

## Managing innovation through cognitive mapping

Table 5.8: A summary of the insights from the deductive rounds

Project	Themes	Localised insights
5. SOFTWARE	Positive results across all dimensions.  There was a theme of team mentorship starting to emerge through which remained in evidence in the rest of the projects.	The framework was able to maintain a shared cognition when it was the technical expert's nature to divide and conquer. The result was a product with a coherent look and feel with integrated functionality.
6. CAROTENE	Positive results across all dimensions.  There was evidence of the framework being used by team members in other projects. The framework was easier to use with senior teams.	The parallel development allowed for the early identification of a fatal uncertainty to the project. The project was eventually shelved due to this issue.
7. EMPOWERMENT	Positive results across all dimensions.  Good operating concepts can give richness to the project purpose and aid concept retention.  The framework appears to be more effective in senior management teams than junior teams.	The process gave insight into the strategy and purpose of the project, and seemed to enable a level of group problem solving, as the group collectively interpreted the data in feedback sessions.

The deductive rounds helped to consolidate the experiences of the facilitator and the results detailed overleaf show a process that has a positive impact on all five of the themes under consideration. The pattern of the relative scoring of the dimensions experienced in the first round was maintained with the team roles again being the weakest and creativity being the strongest. It did, however, become apparent that the framework had limited use for communication outside the group. The rich insights rest upon the process of

developing the map rather than on the maps themselves, hence it is the process which is of value and not the product of the process.

The time ordered explanatory effects matrix described overleaf in Table 5.9 summarises the perceived effectiveness of the process, through a visual representation of the evaluations done by the users, across each iteration of the inductive projects.

Certain patterns emerge from this matrix.

- The scoring across all themes was generally higher than that of the inductive rounds.
- All the themes, with the exception of communication, seem to show a pattern of levelling or diminishing of the theme towards the end of iterations, particularly if the number of iterations was large as was the case for the project SOFTWARE.
- Creativity was again the theme that showed the highest relative evaluation, which is a result of the focus on both the creativity tools built into the process and the overall concept patterning and concept interpretation focus.
- Team roles, was still the theme that showed the lowest relative evaluation. This could be attributed to the fact that the framework in its nature is biased toward concept articulation, ordering and patterning, with the theme of team role being more process-orientated.
- Task tracking showed a slightly higher evaluation than the inductive rounds, but the tendency continued for this theme to weaken toward the end of the process. This indicates that the framework is not effective in task tracking beyond a certain stage in the task. Project 6 shows a weakening in task tracking, but with the small number of iterations it is difficult to draw any conclusions from this.

Table 5.9: Time ordered explanatory effects matrix of the deductive rounds.

Project number	5															6			7			
Variable / Time period number	1 2 3 4 5 6 7 8 9															1 2 3			1 2 3			
1) Communication: Evidence of a common vocabulary Evidence of misunderstandings. Use of map for external communication	++ + 0 --																					
2) Creativity: Evidence of associative thoughts being included & periods of divergent processes	++ + 0 --																					
3) Task relevant knowledge: Does the map represent everything you know? Do you know what you don't know? Accuracy in developing task relevant knowledge	++ + 0 --																					
4) Team roles: Do you know who is doing what? Evidence of duplication of work	++ + 0 --																					
5) Tracking: Evidence of the use of other tools. Time spent on tracking	++ + 0 --																					

## **Chapter 6: Generalised theory and discussion**

The literature review highlighted the five themes that are crucial to managing innovation in the “Skunkworks stage”. The five key themes are: developing a shared cognition, enabling creative problem solving, developing task relevant knowledge, keeping clear task roles, and effective task tracking.

The literature review then considered areas such as cognitive mapping, creativity processes, knowledge management, and project management to establish a basis for a first pass framework within which tasks could be handled. An action research approach was used causing the framework to evolve into the final format of the seven steps described in Chapter 5, section 5.6 (p138-141).

This generalised theory / discussion will follow a structure based on the seven steps of the framework and is summarised in Table 6.1 below.

### **Introduction**

Innovation management in the “Skunkworks stage” centres on developing task relevant knowledge through the targeted reduction of uncertainty and ambiguity.

The framework essentially has two related elements, the first of which focuses on fostering and maintaining a shared cognition amongst the team members. By using cognitive mapping as a means of developing and representing the collective uncertainty (and by default certainty) in the task, the gap between the desired task relevant knowledge and the current state becomes evident. The second element focuses on managing and enabling the TRK. Most



traditional knowledge management processes (Collison et al., 2001) have viewed the development of TRK as the domain of the individual, with the group sessions serving to pool that knowledge. Enabling TRK in the group occurs through the reduction of ambiguity as the team attempts to categorise, re-frame, problem solve and bring to light new linkages in the uncertainties. By the use of cognitive mapping, NGT, knowledge management processes and creativity tools it is suggested that the development of TRK occurs both individually and within the plenary sessions. The method of eliciting a collective cognitive map from ideographic data using discussion methods and processes to build a group map (Nelson et al., 1991) was to be an effective approach and fitted well within the context of innovation teams.

### **Framework steps**

#### **6.1 Capture the task in the centre of the page**

The team is pre-equipped with a collection of literature related to the task and a description of the task, its aims and objectives. This serves to give the team enough information to understand what the task is.

By placing a short description of the task in the centre of the page the team is forced to agree on what the outcome is. This might seem like a simple achievement, but this clear shared sense of the “end state” forms a strong beacon in the stormy seas of team development. While the focus of the research was not on how to describe effectively and agree on the task, the same techniques used to generate and group the uncertainties could be used to develop a shared sense of the task by exchanging the term uncertainty for the words “task description”. The teams reported a higher sense of motivation and direction due to the members’ understanding of how their actions affect the overall task.

This step was developed from the Self Q technique in section 2.3.3 (Bougon, 1983) and was incorporated as a step in the framework for the reasons described above, it was however found that it is sometimes difficult for the team up front to be clear on what precisely the task is

about. Sometimes it was necessary to use the oval technique on the task description itself in the manner described in Appendix A.3 the facilitators guide. The other tacit implication is that the framework only functions on closed ended problems for which the team can reasonably described the desired end state up front.

### **6.2 Silently generate uncertainties**

As social beings, humans are susceptible to the pressures of conforming to the group's norms. Innovation involving team development occurs under tight development timelines and with high levels of personal commitment with the resulting natural tendency for the team to converge on an approach and set of acceptable behaviours. Even high performing teams tend to reach a plateau in their performance in the latter parts of the development. Mechanisms for individuals to explore their own thought patterns away from group pressure are important to prevent group-think (Janis, 1972). The use of Nominal Group Technique (Delbecq et al., 1975), allows an individual to explore his/her own views on the uncertainties in the task context before being subjected to the groups views. This has the advantage of ensuring the best insights from all the team members are explored in a structured manner and the impact of personalities is minimised. It has a second effect of enabling the learning of individuals in the team, because once uncertainties are offered they are sorted and concepts that are uncertain to one member but certain to another are eliminated when the member with the knowledge shares that understanding with the group.

In working with the projects, it appears that mechanisms for individual reflection with subsequent democratic feedback, such as the nominal group technique, facilitate a shared cognition, thereby allowing the team innovation process to move forward more effectively.

The use of self-Q technique (Bougon, 1983) was found to be effective as a question to direct the development of the map, however in some of the teams it was found that the open nature of such a question in more junior teams can be unsettling and the framework does need support from a facilitator that is experienced in the technique.

### **6.3 Grouping the uncertainties (Eden et al., 2002)**

The process of grouping uncertainties occurs through asking the team "What concepts have common elements?" This grouping process facilitates a collective understanding of what is understood by each grouping. The resultant concept retention helps guide the individual behaviour of team members during implementation. This approach was developed from the Oval technique described in Section 2.3.3 (Eden et al., 2002), and was found to be crucial in building and retaining a shared sense of the definition and ambit of a descriptor as well as assisting in the laddering process.

### **Developing operating concepts – an enabling platform**

If the team is questioned on the groups of uncertainties and asked a second question "What descriptor can best describe this grouping?", the group then often offers an apt description (called an operating concept) that they would have struggled to verbalise as a group without using the process. It seems that many of the ungrouped concepts could be viewed as symptoms of an all-embracing "cause", and the process of grouping the concepts moves away from the symptoms and approaches the operating concepts that are rich in communication and shared cognition potential. These operating concepts were used to influence the behaviour of team members as these individuals interpret the meaning of the operating concept in their specific context. The outcome is coherent directed actions on the part of the group, without the need for strong leadership. This step was found through moving away from pre-defined innovation related operating concepts,

predominantly as a result of the project teams reactions against the utility of these pre-defined constructs (Afuah, 1998).

### **Shared cognition**

It was an interesting feature of the projects that often the shared cognition of the team was strong enough to offer advice regarding the actions of an individual in technical areas outside their expertise. The reason the team was able to play this role is that the group was not informed of the detail in the sub-concepts, but understood the relationships between the middle level and operating concepts. This grouping and ordering of the concepts and their constituents into a hierarchy allowed the group to develop a shared cognition and interpret ambiguity more effectively.

### **6.4 Drilling down to develop the map: Rugg (1995)**

#### **Concept - action divide**

It was clear from working in the field of innovation management that many participants struggled to reconcile the bigger conceptual task with the specific details of the actions required to move the project forward. There was a need for an approach that would guide the thinking of a group from the high order concepts down to the specific actions.

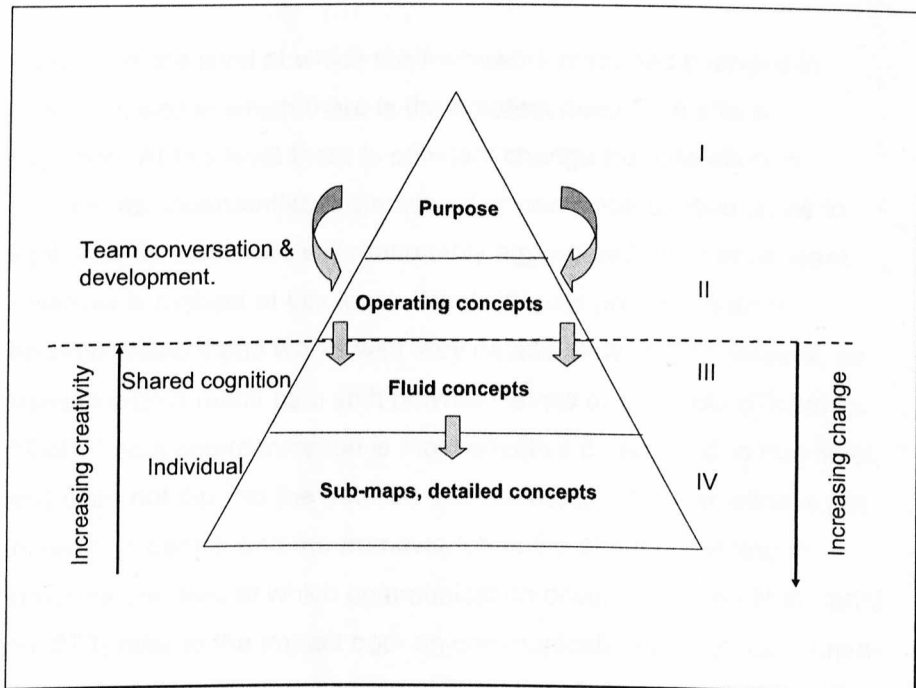
Observing the teams in the different projects it appears that this hierarchical mapping from the task down to operating concepts to subordinate concepts and ultimately events, helps to bridge this divide. Clearly other management fields such as strategy suffer from this "**concept - action divide**". As managers, people are good at conceptual discussions but poor on implementation as there seems to be a divide between the concepts and what actions are needed. The hierarchical mapping as described by Eden (2002) within the context of innovation teams helped focus the teams energy on actions rather than

concepts, but was found that it was only effective when coupled with the brainstorming techniques or to strong a convergence was experienced too quickly. This aspect of hierarchical mapping is not addressed elsewhere in any of the cognitive mapping literature.

### Cognitive separation

Figure 6.1 below represents the nature of the cognitive structural separation that follows through the use of the framework.

Fig. 6.1: The cognitive separation



**Levels I & II** are developed in the first iteration and while on occasions they have changed slightly, they essentially remain unchanged for the duration of the task. These **operating concepts** are aggregated high order concepts that give direction to the fluid concepts. They are formed through team conversation, with this shared vocabulary being part of the shared cognition. The properties of remaining unchanged

over the development path and being cognitively central allow the operating concepts to act as a mediator in the interpretation and implementation of the subordinate concepts

The process of developing the high order concepts was reviewed by a strategist (Manning, 2001), who immediately recognised the potential of the framework in developing a clear business strategy. The operating concepts relate to the key value drivers of the business and the purpose can be likened to the vision of the business.

**Level III** is the level at which the framework manages changes in concepts, and at which there is the greatest need for a shared cognition. At this level there is constant change from iteration to iteration as uncertainties are resolved or new uncertainties come to light. The concepts are still reasonably aggregated and hence team creativity is highest at this level. Creativity plus problem solving become stifled if one works with very detailed low order concepts, as lateral insights result as a shift between levels of concepts (Richards, 1999). Team communication is most effective if restricted to that level, and does not dip into the detailed sub-concepts. This discipline is not inherent in people and the framework has the effect of helping to structure the level at which communication occurs. Fiol and Huff (1992, pg. 273) refer to the impact both on communication and group "sense-making" as this effective communication assists the group's understanding of the concepts and their relatedness, leading toward more effective problem solving.

**Level IV** is the level of detailed sub-concepts which change on a regular basis. This change, which was in the domain of the individual, was by and large not detailed in the aggregate map and was often managed with sub-maps. This level does not generally form part of the

group cognition as it tends to confuse rather than clarify the group's understanding. It was a good discipline to separate the two levels and not allow too much of this detail to clutter the group feedback sessions. Excess information introduces ambiguity, leading to confusion rather than interpretation.

### **6.5 Allocating uncertainties: Knutson, (2001)**

As innovation tasks become more specialised, it becomes more difficult and yet more crucial to link deep specialist areas of activity to the overall task. People who are technical specialists are not often predisposed to working in teams and often do not have deep management or communication skills, which complicates the issue of breaking down the technical silos and facilitating an alignment of cognition. The framework provides a structure for allocating uncertainties. By focusing initially on the hierarchy of relationships in the cognitive maps, and only later on the inter-relationships, the team develops a shared sense of the purpose of the task, the operating concepts, and then understands how those are drilled down into specific actions that will resolve the uncertainties associated with the task. The maps enable a visual means of referencing the relationships between concepts at differing levels, which helps overcome the divide between action and concept and ensures that the team builds accountability for the events at the bottom of the chains. Where there is specific obvious interrelatedness between concepts, the facilitator will tease this out, normally once the map is nearing completion for that iteration. This helps define sub-task interdependence and as a consequence assists in the allocation of the events to the appropriate member/s to explore.

It was found that around the process related dimensions of task allocation and task tracking the map was the weakest as the entire framework was based on concept related ontology's (Kettinger et al.,

1997). Cognitive mapping literature if it is to gain higher utility could benefit from an exploration into how to better combine these to requirements.

### **6.6 Growing and updating task relevant knowledge: Collison, (2001)**

Many of the processes described up to this stage contribute to the development of the task relevant knowledge in the groups. Hence the cognitive mapping and creativity tools help to develop a collective sense of the concept patterns and relatedness which provided a strong platform for collective problem solving. The interregnum period between collective re-mappings however was not unimportant, as the information gathering process to reduce uncertainty and individual interpretation of that information had a large impact on developing the task relevant knowledge.

### **In-between mappings**

It is human nature to want to "go it alone" and many innovations go through costly development processes only to find that vast areas of what has been developed have already been developed in another context. If one were to hold to the philosophy that "there is nothing new under the sun", many developments would happen far more effectively. With such a mindset, the nature of the in-between process is about "architectural innovation" – about finding those silos of knowledge that have developed in other contexts and assimilating them into this particular context. The team members were exhorted to find these specialist pools of knowledge and to extract the relevant information from them. Models as described by Afuah (2003) of acquiring and managing this process could be useful.



The in-between process drew strongly from knowledge management principles the important components of which are reflected in the following (Collison, 2001):

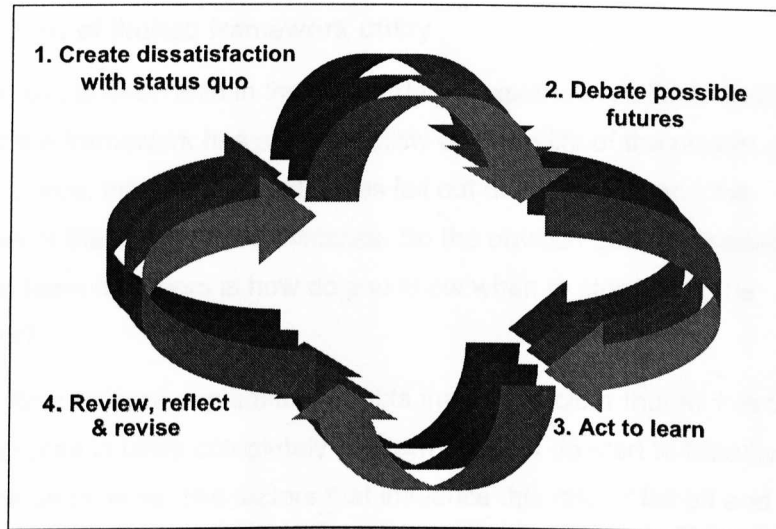
- learning before doing – going out and finding what has been done before and what are the right questions to ask;
- learning while doing – creating time to reflect, and acting to learn;
- learning after doing by sharing the insights gained.

The framework explicitly facilitates these elements in its structure forcing periods where these three stages predominate. In the projects that undertook three group review sessions, the level of shared cognition was not as good as in those groups that tended to meet more frequently. Too frequent meetings were seen to hinder development and were shown to be destructive while too infrequent meeting hampered the shared cognition. In the teams that were working on the task on a full-time basis, a once a week meeting was found to be the shortest practical duration and under these conditions the group's energy and shared cognition appeared to be high.

### **6.7 Updating the team map**

The shared cognition evolved through group discussions and maps went through several iterations. The updating of the map prompted higher levels of group problem solving and team mentoring, particularly in more senior teams. During the iterations of the maps, the teams expressed a philosophy of active engagement depicted in Fig 6.2.

Fig. 6.2: Leading discovering teams



This model essentially reflects how, through its processes, the framework builds and refreshes in the minds of the team a new shared understanding of what actions are required. Through this deeper sense of what is still unknown, dissatisfaction becomes evident, which is linked to a desire to develop actions that reduce the uncertainty in the task. The debate as to what these actions are, facilitated through the drilling down into subordinate concepts gives each team member some event, where they can contribute to developing the TRK. Often due to the nature of the ill-structured problem, the specific actions are inappropriate but they facilitate action in a conceptual space which after review and reflection can often yield richer and more meaningful actions. These insights are pooled again, building a richer sense of the task and the process begins anew. Hence, the map itself acts as a transitional object and acts as an ideographic basis for directing the processes.

This cycle of managing innovative teams seems particularly apt for tasks that are ill-structured and require deep tacit knowledge.

### 6.8 The point of limited framework utility

From the results described in the time ordered explanatory effects matrix, it is clear that the framework has a limited utility over the life of the project. As the project matures, the major uncertainties fall out of the project and the usefulness of the framework diminishes. So the obvious question raised by one of the team members is how do you know when to stop using the framework?

From the time ordered explanatory effects matrix it is clear that all five themes do not decrease in utility completely concurrently, but do start to broadly fall off around the same time. The factors that influence this rate of fall off and at what point precisely does one stop using the framework is clearly an area for further research, but for the purposes of the projects the question was asked, "is it still worth mapping the process?" While the answer was still the affirmative the framework continued to be used.

### 6.9 The Impact on development times

There has been much research undertaken on the stages of development Giget (1988), and terms such as broad research, applied research, piloting and commercialisation are part of current standard vocabulary. There is much to be gained through the parallel development of all these stages of the process. If there are large uncertainties in elements of the value chain, it does not make sense to be using resources to refine small uncertainties out of the first step in the process, only to be halted later by one of the greater uncertainties.

By its very design the framework demands the parallel development of all stages of the development cycle through targeting the largest uncertainties first, no matter where they are in the processes. This aspect was specifically commented on in two of the projects *"The parallel development of all uncertainties helped us to realise early on that the sourcing of finance was*

*make or break and to establish that in our case it was probably a theme that would cause failure unless we secured off take agreements”.*

This parallel development of all aspects of the task as far as possible at that point in time brings to the surface the relationships between the different aspects of the task and forces dialogue between the parties involved in the different aspects. An example is in the flavours project, where it was realised that the market demanded a critical number of flavours in the organic format before the advantages of this organic approach could be considered. This is not apparent at first glance, but the use of the framework forced the team to focus on their uncertainties around the customer's requirements, before too many sunk costs in were incurred on the development components. To be clear the use of the framework does not optimised the development time but it does assist the team to understand and focus on the key uncertainties before getting swallowed into the detail. If any of the key uncertainties are such that they are un-manageable in the context of the framework they are at least identified early on in the process. Hence the reduction of lead time in some projects and the management of critical uncertainties early on are related.

### 6.10 Summary of findings

A summary of the supporting evidence for the framework is depicted in Table 6.1 below

Table 6.1: A summary of the supporting evidence for the framework

Framework steps	Supporting evidence from the projects
1. Task in centre of page 2. Silently generate uncertainties	<p>The team consistently benefited from a discussion to establish a shared sense of the task.</p> <p>The N.G.T facilitated deeper individual thought before offering uncertainties and reduced concerns about ill-conceived uncertainties.</p>
3. Group uncertainties 4. Drilling down 5. Allocating uncertainties	<p>With technical experts often talking past each other, it is important that conversations happen at a consistent cognitive level. The layering of concepts facilitated conceptual relationships. The creative processes ensured a wide field of search for uncertainties and higher levels of group problem solving.</p>
6. Grow task relevant knowledge 7. Update team map	<p>A shared cognition and clear responsibilities in areas for research of uncertainty coupled with action review sessions enabled the interpretation of information, thereby growing task relevant knowledge.</p> <p>With all areas in the cycle of product development being simultaneously explored development cycle times were improved.</p>

## **Chapter 7: Conclusion**

Innovation is an important element of strategic management. Most successful businesses have at some time created new products or services themselves or exploited a market opportunity to utilise an innovation developed by other organisations (Afuah, 2003). Whilst the application of new knowledge features strongly in innovation, there are many uncertainties for managers to face in the management of innovation. Most product innovations involve a cross-functional team (Cooper and Kleinschmidt, 1994) who develop a shared cognition of the particular innovation and the challenges it brings.

Innovation processes, while broadly progressing through the key phases of initiation, development and implementation depend in their detail on the sector, size, the lifecycle of the technology, degree of novelty and the nature of the national systems to innovation (Tidd, Bessant and Pavitt, 2002). These phases of innovation is best undertaken by a process that is integrated with the other systems of the company, are flexible with a customised response to a continuous innovation process and is focused on the development of task relevant knowledge (Rothwell and Gardiner, 1989). The approach should use a balance of pushing the innovation and pulling information from the upstream of the supply chain, i.e. also be responsive to the needs of the customer.

Afuah (2003) suggests the different business models that should be used at the different stages of developing the innovation, depending on the type of task relevant knowledge the team has. He analyses the level of uncertainty or familiarity in terms of task relevant knowledge from a market and technology perspective and suggests that the mechanism used for developing the venture depends on how much task relevant knowledge is internal to the team or the company. In all the projects in this study the markets were new (unfamiliar) but the technology was not new (familiar) and the business model was a joint venture. (Afuah, 2003, pg. 204).

## Managing innovation through cognitive mapping

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From a review of relevant literature, five themes emerged as dominant factors that impact on a project team's capability to manage the innovation process.

They are the teams:

- development of a shared cognition
- creative problem solving
- development of task relevant knowledge
- team roles
- tracking of the task.

These dimensions were used to inform the research design and to evaluate the effectiveness of the cognitive mapping framework developed through the research. This study uses an action research approach (Eden and Huxham, 1996) to develop and test a framework that uses cognitive mapping (Eden, 1992; Huff and Jenkins, 2002) to help project teams capture and respond to the uncertainties surrounding the innovation.

Cognitive mapping is a way of depicting how concepts relate in the eyes of a particular person or group. Maps can be classified as ideographic or nomothetic in design. This classification refers to either the freer interpretation on the basis of clinical theory or the tighter interpretation against statistical norms. The author has tried to steer clear of the need to assert a nomothetic outcome (Daniels et al., 2002), and have designed the research approach so that ideographic methods are acceptable to achieve the objectives of the E\_PUBLISHED><PUBLISHER>Norton</PUBLISHER><ORIGINAL\_Pognition

There is much debate in the managerial cognition literature about the level of analysis possible in cognitive mapping, individual or organisational.

Hodgkinson, Bown and Maule,(1999) prefer to focus on the individual.

However, a number of researchers have shown that cognitive mapping may be applied to groups (Langfield-Smith and Lewis, 1989; Axelrod, 1976; Bougon, 1992; Johnson and Johnson, 2002). Larson and Christensen (1993)

argue that groups can develop a shared cognition which improves their ability to co-ordinate and implement the task. It was the experience of this research that the building of a common vocabulary resulted in a more cohesive directed development team. This is a major contribution of the research.

Methods of eliciting a collective cognitive map hinge upon obtaining a group consensus of the constructs. Techniques include building an average or composite map from individual maps (Wieck et al., 1986; Bougon, 1992), or using discussion methods and processes to build a group map (Nelson et al., 1991). Langfield-Smith (1992) suggests that this is the most useful, as group discussion yields a group map that is more than the common content of the individual maps. This is supported by Eden et al., (1992) who state that the group map is a *“visual interactive model, acting as a form of transitional object that encourages dialogues”*. It is the group discussion method that will be used in the framework being developed here.

Innovation projects were studied in seven organisations. Each longitudinal intervention involved an initial group briefing, and project definition, mapping and re-mapping (frequency of iterations determined by the team), and a debriefing. The first four cases were researched in an inductive way to develop the framework. The next three cases were approached in a more deductive way to test the refined framework. A total of 160 semi-structured interviews were used, together with the observations of the groups using the framework and feedback from their use of what participants refer to as 'Skunkworks'. The opportunities selected for the projects were all small to medium sized companies in similar industries operating in South Africa. The companies were all at the early stage of exploring an innovative opportunity which formed the basis of the tasks for the various teams. The tasks had medium to high levels of complexity.



## **Managing innovation through cognitive mapping**

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The framework being developed aimed to facilitate the development of the group's shared understanding of the task and the outcome of the process should reflect the nature of the task at hand. The map produced need not be unique; however, it should consistently reflect the main concepts that represent the uncertainty in the task. The steps in the framework are listed below.

1. Capture the task in the centre of the page.
2. Silently generate uncertainties (using a nominal group technique).
3. Group the uncertainties (developing a shared cognition).
4. Drill down to develop the map (from high level to subordinate concepts).
5. Allocate the uncertainties.
6. Grow task relevant knowledge (clarify actions and responsibilities).
7. Update the team map.

An explanatory effects matrix is used to present the participants' response to the framework, which contributes to a more general theory on the managerial use of cognitive mapping tools. Whilst the cases examined here need to be interpreted in the context of the specific organisations and their industries, it is argued that the use of this framework can benefit organisations in a variety of industries as an aid to innovation management.

The research found a degree of cognitive separation whereby a boundary between team and individual cognition was identified. Conclusions are drawn on the framework or process for eliciting and updating the teams' cognitive maps in relation to the innovation management literature, and in relation to the leadership of innovation teams. The hierarchical mapping process was found to be a means of overcoming the tendency to discuss high level concepts but not get into the actions needed. This influence that the framework had on the key themes is now described in some detail.

### **7.1 The framework's influence on the key themes**

Through an action research process which involved both deductive and inductive stages the research developed a framework which results show does have an influence on these themes and thereby the TRK. What the influence is and how it is achieved is described below.

#### **7.1.1 Shared Cognition (Eden et al., 2002)**

A shared cognition was to be strongly enabled through the hierarchical mapping, as in order to achieve the mapping, the group had to go through information sharing and collective interpretation processes such as NGT. The shared cognition was achieved primarily in a band of higher to middle level concepts in terms of ordinance, as the lower order concepts are in the domain of the technical specialist. The brainstorming and regrouping processes played a strong role in developing a shared understanding of the patterns and linkages between concepts. The group map well fits the description by Eden et al. (1992) as a transitional object, which is a *"visual interactive model, acting as a form of transitional object that encourages dialogues"*. The map was found to be a useful means to trigger memory in subsequent iterations, and act as a useful visual anchor to the discussions. The shared vocabulary that was evidenced served to initiate and direct the innovation process as this stage of an innovation process is more about initiating than managing innovation. The framework "serves to start off" the conversation and provide a vocabulary to initiate innovation.

#### **7.1.2 Creativity (Richards, 1999)**

The way the framework has an influence on the team's **creative processes**, was through incorporating both divergent brainstorming processes and convergent regrouping processes into the fabric of the framework. The brainstorming occurred at each level of ordinance in the mapping, when the team offered what they felt could be uncertainties to the team actualising the

specific concept under discussion. The same “rules” that surround brainstorming techniques were applied and, once a good number of uncertainties had been captured the convergent aspect of the process was achieved through discarding uncertainties, grouping uncertainties, and re-assigning labels to the groups which offered a rich platform from which to brainstorm again. The dimension of team creativity, relative to the other aspects of the framework, was the strongest, as evidenced in the time ordered explanatory effects matrix (Table 5.9). Through including brainstorming processes, there was a positive impact on the team’s motivation and energy and as a consequence, brainstorming had a far wider effect than purely the creative element.

### 7.1.3 Task relevant knowledge (Collison et al., 2001)

The framework uses uncertainty and ambiguity reduction, as key components of developing task relevant knowledge in the team and as individuals.

**Uncertainty:** For the team to be clear on what they are uncertain, they need to be clear of what task relevant knowledge is already in existence in the team. The approach of simultaneously clarifying what is certain and what is uncertain forces the team to be clear on the gap between what needs to be known and what is already known. The information needed to close this gap was individually gathered through iterative knowledge management processes, and individually and collectively interpreted by processes such as those described by Collison et al., (2001). Without a process that forces the team to be explicit about what is uncertain, there is a natural tendency to underestimate uncertainty in the short term as this tends to reduce anxiety.

This excessive optimism allows the team to refine lesser uncertainties but leave larger uncertainties on the periphery of vision until they cannot be consciously ignored. The framework

enabled the parallel processing of the large uncertainties along the entire development chain, identifying key issues early on in the development cycle. This was evidenced in the CAROTENE project.

**Ambiguity:** Through a combination of hierarchical mapping, creativity tools and a development of the cognitive relationships, the relationships and linkages between uncertainties were made explicit, which increased the possibility of the team using these ambiguity reduction tools to convert the information through problem solving and problem framing into interpreted knowledge.

The use of a framework that deals with both uncertainty and ambiguity helps to ensure that, as the map evolves, it focuses not on representing the thoughts of the team but on the decisions that need to be associated with those thoughts.

### 7.1.4 Role development (Sundstrom, 1999)

The team's role development was enabled through the previously mentioned process of allocating events. While in most cases it was the technical person/s to whom the event was defaulted to it was interesting that in cases where two people from differing functional areas (such as research and marketing), with some input into the issue were co-jointly assigned an event, the strongest insights were experienced. This can be attributed both to the parallel processing aspect and the advantage arising when differing people tackle the uncertainty from different points of reference. The active creation of mutual co-dependencies and sub-task interdependencies in the group is a theme that Morgenson et al. (1997) describe as a feature of high performing teams. There was evidence that the team mentors members through the shared vocabulary of the middle level concepts.

### 7.1.5 Task tracking (Knutson, 2001).

Task tracking was achieved at each iteration of the map, through assigning to a group member/s the lowest order concepts (called events) to explore further. This was done on the back of the concept card with dates for delivery included if relevant. The linking of the high, middle and low level concepts provided a clear path to action by preventing the discussion from wallowing in over-generalisations and by directing it into the specifics of what needed to be done or to be found out. Observing the teams in the different projects, it appears that this hierarchical mapping from the task down to operating concepts to subordinate concepts and ultimately events helped to ensure the task is effectively tracked and linked to the concepts. Clearly other management fields such as strategy suffer from this **"concept - action divide"**.

Task tracking was one of the weaker aspects of the framework, as evidenced by the time ordered explanatory effects matrix (Table 5.9), due to the framework being concept rather than process orientated. This aspect is normally complemented in the third and subsequent iterations of the framework by standard project management tools such as a GANTT chart, or even simple "to do lists" to collect and represent the events. The high level of uncertainty in early iterations of the map forced un-mapping and remapping which made task tracking more difficult.

### **7.2 A summary of the framework's influence on the Skunkworks stage**

A summary of the critical dimensions, as they relate to the Skunkworks stage of innovation management together with the researcher's comment on what the influence is and how the influence is manifested through the framework, can be summarised as follows.

## Managing innovation through cognitive mapping

Table 7.1: A summary of the influence on Innovation Management

Aspect in innovation management	Influence	How the influence occurs
Shared cognition and effective communication.	Hierarchical cognitive mapping.  Cognitive separation.  Uncertainty as a focus for sharing what is known and what is unknown by team.	Processes of ordering, grouping and laddering concepts facilitate a shared understanding of concepts. Laddering.  The iterative use of information gathering, interpretation and re-mapping.
Motivating innovation teams.	A deeper shared understanding of the overall task	A deeper sense of what is uncertain or unknown creates a response of "dissatisfaction" resulting in action to close this gap.
There needs to be place in any innovation process for independent thought and action.	Creativity – divergent processes.	Nominal group technique and brainstorming.
Development of task relevant knowledge.	Uncertainty as a focus to make explicit what is unknown.  Map updating: Learning before, during and after doing.	Clarity in what was uncertain coupled with the processes from knowledge management for the interregnum periods facilitated information gathering to use for individual and collective interpretation.
Communication.	Cognitive separation: by developing a shared cognition at the right level of detail allows for a higher level of concept retention and a basis for a shared vocabulary.	A hierarchical laddering of concepts.
Developing a distance from your task.	Team mentoring through the feedback processes.	Cognitive separation.
Fast development times.	Parallel development of task uncertainties.	Forcing the team to deal with all uncertainties simultaneously forces faster development cycles.

### Localised learnings

Teams gave increasingly positive feedback on the mapping process across the projects from a number of perspectives, though not all team members commented on all five key themes. Localised learnings included insights resulting from: the parallel development elements, the identification of a new

potential market very early in the process, a smooth development path, and cohesiveness through mentoring processes in the team.

The explanatory effects matrices for the seven cases reflect a high level of satisfaction with the framework and the mapping, which supports the use of cognitive mapping in the specific innovation context.

### ***7.3 Drawing conclusions from action research***

In drawing conclusions from action research, Reason et al., (2001, pg. 454) suggest five issues for determining the quality of the research, asking whether it is:

- Explicit in developing a praxis of relational participation?
- Guided by reflexive concern for practical outcomes?
- Inclusive of a plurality of knowing?
- Worthy of the term significant?
- Emerging towards a new and enduring infrastructure?

Taking these questions in turn, the first is possibly the most easily evidenced in this research. The fact that participants were members of naturally occurring project teams, not individuals selected by the researchers, who shared the imperative of successfully managing an innovation, meant that they were keen to participate in any learning process. Full participation was ensured by employing the nominal group technique as well as the oval mapping technique. The facilitator's role was to give structure to the team's discussions and ensure that their exchanges were on a consistent cognitive level. To perform this role well involved drawing from extensive experience as a facilitator of learning, being well-informed about the theory and practice of innovation management and using preliminary interviews to gain background information on the particular innovation.

The second issue is evidenced by the positive feedback from participants on the process, extracts from which are presented in the explanatory effects matrices. The key to the usefulness of the framework lies in the iterative or dynamic nature of the mapping, employing the laddering technique to maximise the utility of the maps. For participants to be willing and able to act on what was learned in the course of their research, they had to go beyond broad conceptualisation of the uncertainties to actionable concepts. There is evidence of action and reflection taking place in all seven cases.

Reason et al., (2001, pg. 451 - 452) explain three aspects of the third question. Firstly, ensuring conceptual-theoretical integrity, this can be difficult to achieve when investigating a complex phenomenon in a number of different organisational settings. However, there is an extensive literature review underpinning this study, and the author has shown how key prior work informed the study in section 2 and how these concepts and theories link with the results and emergent framework in Tables 6.1 and 7.1. Secondly, extending peoples ways of knowing and in particular sharing and making tacit knowledge more explicit is a key feature of the cognitive mapping approach adopted. None of the organisational participants were familiar with cognitive mapping as a way of knowing before they took part in the research. Their insights in relation to the innovation projects contribute to a little known way of developing task relevant knowledge about the uncertainties of innovations, though this researcher acknowledges previous work by Swan (1997) in this field. Thirdly, intentionally choosing appropriate research methods exercised the minds of the researchers for some months before agreeing upon a research strategy and entering the field.

The fourth question, one of significance, is often difficult to answer definitively where the unit of analysis is a project or case. How many cases would be judged to be significant? Though the significance cannot be fully reflected, it may be addressed in this research by noting the number of interviews conducted from Tables 4.1 and 4.2, totalling some 160. Another indicator is



the timescale of three years over which the longitudinal interventions took place.

Significance is not just about volume of course, it also involves the 'so what?' theme. Part of this is evidenced through the participants' feedback and part through the negotiation of a book contract to publish many of the ideas drawn from the study, especially from project 7, contributing to Black Economic Empowerment (BEE) in South Africa.

The last question that of enduring consequence, is easier to respond to after the passage of more time. However, whether or not the learning from this research endures the academic test of time in terms of published outputs and citations, it has had enduring consequences at the local level in the participating organisations, where projects have passed the investment appraisal stage and are now under implementation. Each project that is implemented has a team of people whose knowledge has been enhanced by the research process.

### **Areas for further research**

As pointed out in section 6.8, the aspect of the point of limited utility needs to be researched to establish when and why it occurs as this is a limitation in the framework currently. A related aspect is the utility of the framework itself within other contexts. It was specifically developed and tested on innovation projects. Innovation projects are themselves just a part of a broader set of complex ill-structured problems that require a solution from teams. Many business problems could fall into this category and it would be extremely useful to establish if the framework is effective outside the specific project environments it was developed for and tested on.

### **7.4 Summary**

This research explored a problem as represented by two propositions namely that a form of cognitive mapping could be used in an innovation team, to develop a shared cognition of a project's task relevant knowledge, and that the use of this framework could direct the growth of task relevant knowledge.

The researcher concludes that these two propositions have been answered on the basis set out in Sections 7.4.1 and 7.4.2 below.

#### **7.4.1 Shared Cognition**

By using a form of cognitive mapping that is hierarchical, the framework facilitates a process to develop a shared vocabulary which helps to articulate ill-structured problems. This was evidenced through the high level of retention and use of this shared vocabulary. This was seen through feedback from the users and through the observations of the researcher during the group processes. The teams under research appeared better able to maintain a productive conversation around middle order concepts and did not digress into levels of detail which all the team could not follow.

#### **7.4.2 Development of task relevant knowledge**

The framework used uncertainty as a focus to make explicit what is unknown, which served to direct the teams focus more towards what is unknown than rehashing what is known. When this was coupled with processes to facilitate learning before, during and after doing, and used together with interpretation processes, this facilitated ambiguity reduction. In the seven cases studied the use of the framework reflected high levels of utility in the time ordered explanatory effects matrix (Table 5.9) across all five of the key themes.

*The localised learnings from using this framework* are context specific and only contribute to organisational learning, whereas the process observations are generalisable on the basis of section 7.3 above, from the seven cases studied. Hence the framework has sufficient merit as a generalised theory, to offer innovation team members in other organisations a useful tool for developing a shared cognition of a project's task relevant knowledge, and for directing the growth of that task relevant knowledge.

## Appendices

### *A.1 Facilitator's notes*

This serves not as a comprehensive facilitator's handbook, but rather as a few areas to be noted while facilitating using the framework. The description follows the format of the steps of the framework.

#### **Step 1: Capturing the task**

While the framework is not designed to assist in the formulation of the task, in order to clarify the definition of the boundaries of the task the steps 2 & 3 described below can be followed (if the task needs clarification) with these two changes.

- The word "uncertainties" should be replaced with the question to the team (and perhaps its manager or task originator) "what is this task about".
- The grouping process should not stop at three to four groupings, but, once they are formed, there should be a further grouping into one descriptor which is the task definition. This can further be sharpened and delineated by on the back of the concept card, specifically capturing what the group believes is involved in the task.

#### **Step 2: Generating and capturing uncertainties**

This step was following the process recommended by NGT, which is a structured form of uncertainty generation, with up to 10 participants and an experienced facilitator.

A short summary of the NGT (Delbecq et al., 1975), which has been modified into the terminology of this research is set out below.

### **Underlying principles**

NGT is based on three fundamental, research-based principles.

- 'Nominal' Groups are thought to generate more, quality ideas than interacting groups typical of classic brainstorming. A nominal group consists of several people who are prepared to work as a team to develop a shared sense of the task relevant uncertainty. This sharing and consensus building around task uncertainties promotes a sense of involvement and motivation within the group.
- The 'round robin' element provides encouragement and equal opportunities for all members to contribute. Contribution from all participants is encouraged and every individual's uncertainties are given equal standing, whether unique or not.
- Reliable communication requires that the recipient's understanding of a message be checked with the sender, especially in the case of new uncertainties being put forward. Checks for accurate communication are built in to the technique.

### **Standard procedure**

Various forms of the procedure can be undertaken, however, the classical form suggested by Delbecq et al.,(1975) uses the steps described below (modified into the terminology of this research).

1. Anonymous generation of uncertainties in writing, begins with the facilitator stating the problem and giving the participants up to 10 minutes to jot down any initial uncertainties privately.
2. Round-robin recording of the uncertainties, allows each person in turn to read out one of their uncertainties, which the facilitator writes up on a flip chart for all to view. This is repeated going around the groups until all uncertainties are exhausted and any obvious duplicates are eliminated.

3. Serial discussion to clarify uncertainties and check communication is encouraged by the facilitator. Working through each uncertainty systematically asking for questions or comments with a view to developing a shared understanding as to whether what has been offered is indeed an uncertainty to the entire group or, if individual members might be able to offer some input to eliminate the uncertainty. Discussions are calm and controlled to aid clarification of the uncertainty, they are not heated debates.
4. Further discussion and voting on the relevance of the uncertainty, then takes place. If voting is not consistent, steps 3 – 4 can be repeated and any ideas that received votes will be re-discussed for clarification.

### **Step 3: Grouping uncertainties**

The rationale behind the grouping process was the view that, if a group is asked “What concepts have something in common?”, they readily respond without hesitation. When asked a second question “What descriptor can best describe this grouping?”, the group then often offers an apt description of a core operating concept that they would have struggled to verbalise as a group without using the process. The assignment of descriptors should again be a process of debate, with the chosen descriptors exhibiting the characteristics mentioned below.

- They must be short – two to three words
- They should not be very common terms (e.g. Quality), as they should have a rich meaning in the context but should be without strong associations outside the context
- There should be a bias away from the noun in the description of the uncertainty and a bias towards the adjective or verb that relates to that noun.

### **Step 4: Drilling down**

This process was a repeat of the steps 2. and 3. at each level with one major difference; during the capturing stage at each level the brainstorming process can contribute to new uncertainties as the referencing to the higher order concepts can cause lateral associations to emerge and guide the derivation of new lower order concepts (de Bono, 1992). The facilitator should encourage the referencing to the context of the related higher order concepts to facilitate these lateral associations.

One may find that the group does not have enough knowledge to be able to drill down to any detail. This is normal in the early stages of the project and the facilitator should allocate an exploration of each uncertainty at the bottom of a hierarchical chain to pairs of group members.

### **Step 5: Allocating uncertainties**

Where there was specific obvious interrelatedness between concepts, the facilitator should tease this out, normally once the map is nearing completion for that iteration. This can be done through a question such as "Do any of these concepts have clear relationships besides those indicated?" This helps define sub-task interdependence and as a consequence assists in the allocation of the events to the correct member/s to explore. While in most cases it is the technical person/s to whom the event is defaulted, it is good to encourage cases when two people from differing functional areas (such as research and marketing), with some input to the issue are co-jointly assigned an event as then strongest insights are experienced. The active facilitation of mutual co-dependencies and sub-task interdependencies in the group is a theme that Morgenson et al., (1997) describe as a feature of high performing teams.

### **Step 6: Growing task relevant knowledge**

The intervening period was is significant in the process of growing TRK, in fact this is when the main growth of individual TRK happens. The team should be strongly encouraged to access pools of specialist knowledge which can contribute to their understanding of the task. Business linkages should be sought that actively assimilate entire areas of knowledge into the team. The team members should also be encouraged to liaise with other team members who are researching areas of relatedness.

### **Step 7: Updating the team map**

The process of deciding on what remains in the map, what elements in sub-maps would be incorporated is a subjective one. The facilitator should be endeavouring to maintain a layer of concepts just below the operating concepts that can be used as a consistent vocabulary to the team as they re-conceptualise what is involved within those concepts as new insight comes to light. The elements in the sub-map which contribute to that layer of understanding could be incorporated, but care should be exercised in including detail which could clutter the map without adding anything.

### **The role of the facilitator**

The map being evolved is not unique, but it does need to represent the key uncertainties inherent in the task. There is no one right or wrong map or way of facilitating. It has been found that senior teams with good management experience, adapt to the process more easily and have less need for strong facilitation. Hence the facilitator should attempt to adopt the following approaches listed below.

1. Internalise all the pre-reading and develop a good understanding of the task as do the other team members.
2. Attempt to note in the discussions the amount of creative divergent discussion in comparison to convergent discussion and ensure a good



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balance is achieved between the two by managing the time associated with the tasks.

3. Monitor the usage in discussions of the operating concepts. If they are used frequently, then they are fulfilling their role.
4. Outside the group sessions attempt to assess the level of shared cognition and concept retention.
5. Monitor any evidence of failure of communication and establish its source.

## A.2 Semi-structured interviews sheet example

PROJECT DESCRIPTION: gkn

DATE: July - October 2008

INTERVIEWEE: DM

Map update number: 3

Variable / Team member	1	2	3	4	5	6	7	8
<b>1) Communication: (shared cognition)</b>								
Evidence of a common vocabulary	0	+	++	+				
Evidence of concept retention	+	+	++	++				
Use of map for external communication	0	0	+	+				
<b>2) Creativity:</b>								
Evidence of divergent insights	0	+	++	++				
<b>3) Task relevant knowledge (TRK):</b>								
Does the map represent everything you know?	+	+	++	+				
Do you know what you don't know?	0	+	++	++				
Accuracy in developing task relevant knowledge	+	+	++	++				
<b>4) Team roles:</b>								
Do you know who is doing what?	0	+	++	+				
Evidence of duplication of work	+	++	+	0				
<b>5) Tracking:</b>								
Evidence of the use of other tools	0	+	++	+				
Time spent on tracking	+	+	++	+				

<b>Table Key:</b>	++ very effective	+ effective	0 neutral	- ineffective	-- very ineffective
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Other information of relevance:

Had some focus on unimportant areas. Comment "Vivid understanding of the big picture" - Iteration 3. Good progress in sub-maps and inter-maps. Map gets complex toward the 6th iteration.
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### A.3 Glossary of terms

These definitions are specific to the context of the research.

- 1) **Action / concept disconnect:** is a term that describes the clear disconnect that exists in developed societies saturated in information between what people understand conceptually and what they actually are able to translate into action.
- 2) **Ambiguity:** is the state of a system as a consequence of several possible interpretations being possible.
- 3) **Cognitive retention:** the ability of the team members to retain an understanding of the concepts discussed in the cognitive map.
- 4) **Event:** an event was taken to refer to a low level concept which is sufficiently clear to ensure that the steps required to actualise the concept are definable and actionable. This classification of an event is a subjective evaluation.
- 5) **Ill-structured problem:** a problem with either high uncertainty or ambiguity.
- 6) **Key themes:** the main themes that have an influence on the team's effectiveness in the context of the research.
- 7) **Operating concepts:** the three or four high level groupings that develop one level below the task description and which tend to serve as a guide to the thinking of the group over the period of the project.
- 8) **Task relevant knowledge (TRK):** the knowledge that the team requires in order to actualise the defined objective.
- 9) **Shared cognition:** the ability of the team to retain a shared understanding of all the issues that surround the task and the task development.
- 10) **Task tracking:** this is defined as a clear allocated locus of responsibility, coupled with a directed development.

- 11) **Uncertainty**: the state of a system as a consequence of the increased variance between the knowledge domain of the team and the TRK.

### A.4 A sample interview

Project: Fish

Map Number: 2

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#### Data Interpretation colour code:

1) <i>Communication: (shared cognition)</i>	C
2) <i>Creativity:</i>	C
3) <i>Task relevant knowledge (TRK):</i>	C
4) <i>Team roles:</i>	C
5) <i>Tracking:</i>	C
<i>Comments on steps</i>	C

#### Data interpretation method:

Any comments from the semi-structured interviews that in the view of the researcher could be grouped specifically into any one of these six sets was highlighted with the respective colour and transported into a document that contains all the comments for that project that relate to that set. Once in a single set comments that carry a similar theme are grouped together to assess the depth of evidence relating to that theme. Any evidence pointing in the contrary direction was also included into the set. The sets were also generally grouped into the strengths or weaknesses relating to that set and the data was analysed for patterns and insights. Input was often requested from an outside observer or the project team leader.

Comments not clearly fitting into the six sets were also grouped into a single "un-categorisable" set and sorted into strengths and weaknesses.

Pieces of these sets were chosen to be quoted in the thesis to show some basis of the changes to the framework without having to drown the thesis in large volumes of transcripts.

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*A transcript of an interview is included below for the purposes of illustration. Please note that this transcript has sections edited out that were of a technical nature, discussing the detail of the particular project both to protect confidentiality as requested by the client and to allow this Appendix to flow better.*

**Q: Researcher:** Would you please offer a review of your experience of the last mapping session?

**Respondent:**

Once technical familiarity sets in on any given innovation project, in my experience the natural desire to push the frontier of what is unknown disappears very quickly so it was facing the unknown factors head-on and dealing with them that gave me confidence in Skunkworks. This is not normal for human nature, especially technical experts who always must seem to be in the know. The ability to deal with this characteristic of our apprehension toward the unknown, by focusing on and reducing the uncertainty is a strong aspect of the process. For me reducing the uncertainty factor of any given opportunity drove the rapid learning. I liked to the aspect of systematically pushing uncertainty to the point of placing a "tick" on any given topic. I felt that the process was extremely helpful in building a shared understanding of the task as we could all visually picture each-others area of focus which directed the conversation and give is common terms and the group seemed to gel nicely around this aspect don't you think?

Between mappings I have been able to for my allocated area to focus my day-to-day knowledge acquiring and not flit all over – the boundaries were clearer, so I found the periods between mappings as important as the mappings themselves. I have been trying to build a smaller map of my area alone to track what I am trying to do. Could I use it to explain my area to the group in the next mapping session as I feel a bit exposed standing there trying to explain everything I have been exploring with the group without any supporting materials?

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The only issue I can point to is that it would be difficult to learn how to approach this process from a book as it seems to be strongly dependent on an experienced facilitator. There is a significant difference in my knowledge about the project when it started against my knowledge now after this session which is understandable as that's the point of the project. I can say that due to the framework I feel that I have a stronger grip around my role in the overall project, but did find that this started to weaken over time so I think the update sessions are very important. I was unsure as to how much detail to bring to these group sessions, do you think we are having them often enough and I presented my section properly?

**Researcher:** What did you learn by using the Skunkworks process?

**Respondent:** After we finished with this last map I feel we have some shared vision around: The direction of any environmental issues in our innovation. We also were encouraged to establish strong relationships with outside experts inside and outside the business which was a good aspect of Skunkworks, its amazing what's already known out there – environment impact assessments had already been done, which saved us a huge amount of effort.

We had identified alternative paths of development and the Skunkworks process was efficient and flexible. I also found the free environment provided by this methodology allows the team to think laterally. I like the format as many generations are required as ideas, they are all captured and democratically handled, I think it mediates the balance of power in the group. I have always found brainstorming a difficult process, its not really natural for us, but when using Skunkworks it was easier to generate ideas and they were quickly more focused.

I suppose this is normal for brainstorming but the pause to think and write-up your ideas is great – it stops “\$%^” being offered. The drilling down helped ensure the conversation did not wallow in platitudes and comfort zones but we are pushed to get down to the nuts and bolts, but I did see some of the normal group power plays.

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**Researcher:** Do you have any other comments to make?

**Respondent:**

The functional groupings helped me to quickly visualise the problem in simple terms without getting caught in a ton of detail – kind of being able to sort the wheat from the chaff – clarify what's core to the project and all agree on it. These visual aspects of the mapping allowed for a high level of concept retention for me which is not natural to me, so I like the visual aspects of this process

What I think makes the process most effective is the fact that the other members of the group are not allowed to criticize or comment on other members' ideas and you have the time to think through what you are uncertain about outside the group pressure and the opportunity to explain what you mean without being interrupted. (Note researcher: support for positive support for nominal group technique).

**Researcher:** What could be improved in the Skunkworks process?

**Respondent:**

I have tried using this process on other projects I am involved in, it has helped progress the innovation process, but I found that its ability to have a meaningful impact wanes as the project matures, how do you know when to stop using the framework? (Note researcher – something to address for future research – end point is not clear)

When tackling a project of this size and magnitude the Skunkworks helps me find a place to start, and from then on the drilling down to the specifics using uncertainty gets down to what counts in a structured way so people can't hijack the process easily. The Skunkworks gave me direction to my area of research, which is the market function. I found that when doing my area I felt at ease to write down whatever came to mind and didn't feel restricted, but in other projects I feel some group pressure issues. I found the brainstorming great as it allowed me to give ideas which in



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██████████ I found that although my ideas where free, I was following a flexible process which reassured me but I can picture some people who don't have the same level of experience in innovation type projects finding the freedom and flexibility a bit too unstructured – this process is a world apart from traditional work break done processes we would usually be using and takes some orientating and practice – you would have to persevere to really get used to using this process. I also think that the boundaries between ideas are not always as clear and crisp in reality as the map presents

**Researcher:** would you please rate these five aspects of the Skunkworks process?

**Respondent:** (Goes on to rate five key themes on semi-structured questionnaire)

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